SCIENCE

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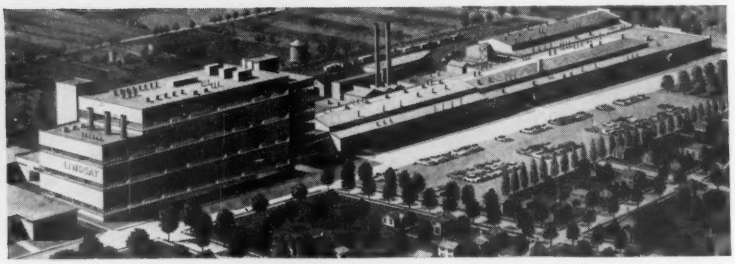

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Loaded Dice

Unfortunately, though doubtless inevitably, the question of the effects of radiation upon human health has become a subject for partisan political debate and has become linked with questions of national power and prestige. Thus, the great debate about the effects of radiation cannot readily be conducted in the dispassionate atmosphere of a scientific discussion. In this issue of *Science*, E. B. Lewis has taken an important step in bringing us the kind of information we need to conduct such a discussion.

But first a few reminders of the debate. Albert Schweitzer recently called for a halt to weapons testing and said that the tests were "creating danger for the human race." Willard F. Libby, commissioner of the U.S. Atomic Energy Commission, replied that the current radiation exposures from fallout are "very much smaller than those which would be required to produce observable effects in the population." Linus Pauling, professor of chemistry at California Institute of Technology, contended that at least 1000 persons would die as a result of the forthcoming British tests of thermonuclear weapons. In rebuttal, the Earl of Home, leader of the House of Lords, said, "We have no information that any deaths have been caused by the Russian and American explosions during 1956–1957."

The hazard—and no one denies that there is some hazard—comes not only from weapons testing. As Bentley Glass has recently emphasized, the hazard from nuclear reactors for power production is a greater potential threat than that from weapons testing. This threat will increase as a result of the greatly enlarged programs now planned. The United Kingdom is now planning to triple the program for power production within the next decade, and the Euratom nations have recently announced plans for a program to produce 15-million kilowatts of power by nuclear means. These developments will pose enormous difficulties in the safe disposal of radioactive wastes.

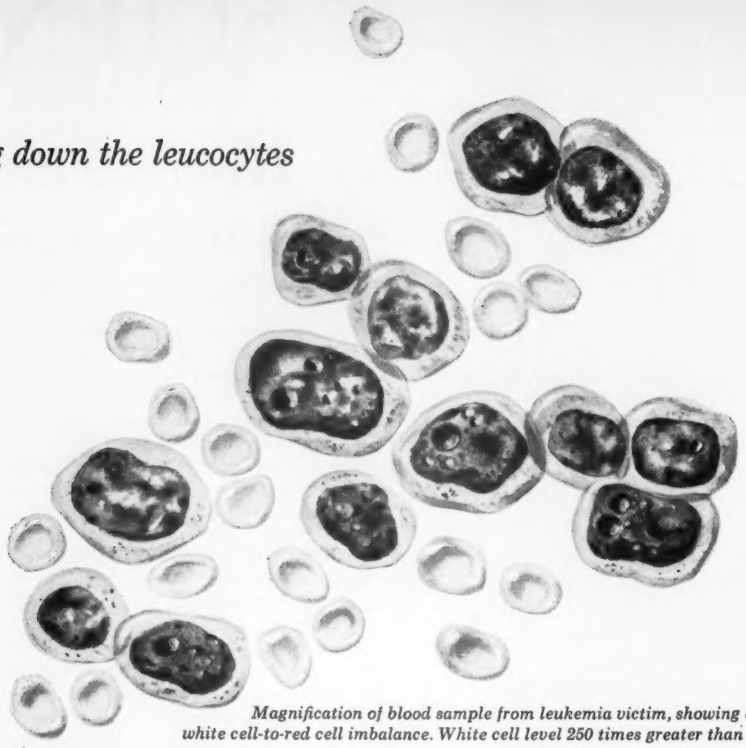
We urgently need to have quantitative information about the effect of radiation on human health. Much is already known about the effect of radiation upon health and longevity in the fruit fly and the mouse, but it is obviously unwise to rely on extrapolation of these data to man. Man is, as has often been remarked, a difficult experimental object. But much can be learned about his biological reactions by appropriate statistical and epidemiological studies.

E. B. Lewis (p. 965) shows that there is a direct linear relation between the dose of radiation and the occurrence of leukemia, a fatal disease characterized by increases in the numbers of white blood cells. The meaning of such findings is that any amount of radiation takes its toll of the population and any increase takes a greater toll.

Thanks to Lewis, it is now possible to calculate—within narrow limits—how many deaths from leukemia will result in any population from any increase in fallout or other source of radiation. And for the individual it is possible to calculate the probability of death from leukemia as a result of any particular dose of radiation. We are approaching the point at which it will be possible to make the phrase "calculated risk" for radiation mean something a good deal more precise than the "best guess."

It is apparent that the atomic dice are loaded. The percentages are against us and we ought not play unless we must to assure other victories.
—G. DuS.

Slowing down the leucocytes



Magnification of blood sample from leukemia victim, showing extreme white cell-to-red cell imbalance. White cell level 250 times greater than normal.

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Leukemia and Ionizing Radiation

E. B. Lewis

Quantitative estimates of the genetic effects of ionizing radiation on human beings have been carried out by a number of investigators (*1–3*). Estimates of this kind involve extrapolating from induced mutation rates in such organisms as *Drosophila* and mice. Quantitative estimates of the somatic, or "direct," effects of radiation must also be attempted if the biological hazards of ionizing radiation are to be fully assessed. In the case of direct effects, it is particularly difficult to extrapolate from results with lower organisms, and it becomes important to have data on man himself.

It is the purpose of this article to examine the evidence for the induction of leukemia in man by ionizing radiation. Although ionizing radiation has been implicated in the production of other human malignancies, such as bone tumors (*4*) and thyroid carcinoma (*5, 6*), only the data on induction of leukemia seem sufficiently extensive to warrant a study at this time of the quantitative relationship between incidence of the disease and dose of radiation. Evidence bearing on this relationship is drawn from studies of leukemia among four groups of individuals: (i) survivors of atomic bomb radiation in Japan; (ii) patients irradiated for ankylosing spondylitis; (iii) children irradiated as infants for thymic enlargement; and (iv) radiologists. An estimate of the probability of developing leukemia per unit dose of radiation (*7*) per time unit is derived for each of these groups. This probability of radiation-induced leukemia is discussed and its application to a specific example of a possible radiation hazard—namely, radiostrontium—is outlined. Certain properties of the disease, relevant to the radiation studies, are presented first.

Dr. Lewis is professor of biology at the California Institute of Technology, Pasadena.

Description of the Disease

Leukemia is a malignant disease in which the leucocytes undergo a more or less unrestricted proliferation. The "acute" form of leukemia differs from the "chronic" form, not only in being usually of shorter duration, but also in being a more severe disease with a higher percentage of immature white blood cells in the circulating blood. Another classification of the leukemias is based on the type of white blood cell predominating in the marrow or in the circulating blood. The two most common of these types are known as "granulocytic" (or myelogenous) and "lymphocytic" (or lymphatic). The presumption is that the granulocytic type arises in the red bone marrow. The lymphocytic type is thought to arise in the lymphatic elements of the blood-forming system (thymus, spleen, and other lymph glands), although the marrow is not excluded as a source for this type.

Spontaneous Incidence of Leukemia

In 1947 Sacks and Seeman (*8*) reported that the recorded death rate from leukemia had increased steadily from 1900 to 1944 and at an accelerated rate after 1930. The death rate has continued to increase (*9*). By 1954 the crude mortality rate for leukemia among the U.S. white population had reached 68 per million individuals per year (*10*) compared with 42 per million in 1940 (*11*). The male and female crude death rates in that population were 79 and 58 per million per year, respectively, in 1954 (*10*). The observed increase in death rate from this disease may be partly due to improvements in diagnosis. Other factors may also be responsible, such as the increased exposure of the population to ionizing radiations employed in medicine and dentistry, as was recently discussed by Dameshek and Gunz (*12*).

MacMahon and Clark (*13*) have recently studied the spontaneous incidence of the common forms of leukemia. They have attempted to determine the total number of valid cases diagnosed among residents of the borough of Brooklyn from 1943 to 1952, inclusive. In this study the over-all ratio of acute to chronic forms among the white population was nearly 1/1 (726/732), but there were marked differences in the incidence of these two forms with respect to age at time of diagnosis, as is shown in Table 1 (*14*). The ratio of granulocytic to lymphocytic types in the Brooklyn study was 1.6/1 (512/318).

Leukemia in Hiroshima and Nagasaki

Studies of the incidence of leukemia among survivors of the atomic bomb bursts over Hiroshima and Nagasaki have established that ionizing radiations induce leukemia in man (*15–17*). Table 2 summarizes the incidence of leukemia in terms of four concentric zones about the hypocenter (the point on the ground under the aerial burst). This table includes only those cases of leukemia which were (i) diagnosed during the period January 1948 to September 1955, inclusive; (ii) resident in the city at the time of diagnosis (Hiroshima) or at the time of death (Nagasaki); and (iii) considered by several criteria to be valid cases of the disease (*18*). For each zone, the estimate of the number of exposed survivors resident in Hiroshima as of October 1950 (*17*) has been combined with the corresponding number for Nagasaki (*15*) to obtain a combined population estimate for both cities.

Lange *et al.* (*16*) have studied the pattern of types of leukemia in the exposed and unexposed populations of Hiroshima and Nagasaki. They conclude that radiation induces the same pathological types that are found spontane-

Table 1. The spontaneous incidence of leukemia for the white population of Brooklyn, N.Y., 1943–52, according to chronicity. Data of MacMahon and Clark (*13*).

Age	Percentage in age interval	Incidence per million per year*		
		Acute	Chronic	Total
0– 9	15.3	48	1	49
10–19	13.5	24	2	26
20–29	16.5	12	6	18
30–39	16.5	20	14	34
40–49	14.8	22	28	50
50–59	11.8	44	64	108
60–69	7.6	58	133	191
70+	3.9	59	182	241

* The incidence of "subacute" and unknown types of leukemia have been allocated to the observed incidences for the acute and chronic forms in the proportions in which the latter were diagnosed at each age interval (*14*).

ously and, as far as can be judged by the limited data, induces them in roughly the same relative proportions that occur spontaneously. This is especially evident in the case of chronic lymphocytic leukemia, which is rare in both the exposed and unexposed Japanese populations, whereas it is the most common form of leukemia after age 50 in the United States (*13*). Lange *et al.* found no marked influence of sex or age on the incidence of leukemia among the exposed populations. However, they point out that, for a number of reasons, the data are not very satisfactory for assessing the incidence in individuals under 5 years of age (*19*).

The published accounts of leukemia in Hiroshima and Nagasaki have not contained estimates of the doses received by the bomb survivors. Recently, however, distance-dose curves for these cities have been published (*20*). These curves give, for each city, the relationship between the slant distance from the burst and the "air" (unshielded) dose of gamma rays and of neutrons. From this information, curves have been constructed (Fig. 1) showing the relation between distance from the hypocenter and the combined "air" dose from gamma rays and neutrons (Fig. 1) in rem (*7*). In computing the latter dose, it has been assumed that the relative biological effectiveness (RBE) of neutrons for inducing human leukemia is 1.7. This value is chosen since Dunning has recently stated that "for generalized whole-body effectiveness it is thought that 1.7 is a reasonable representative value for neutrons from a nuclear detonation" (*21*). This is believed to be a conservative estimate for the RBE, since Upton *et al.* (*22*) found that the RBE for induction of leukemia in mice by fast neutrons is somewhat lower than this.

In the absence of precise knowledge of the distribution of survivors within the different zones about the hypocenter, it is conservative to take the mean "air" dose for a zone as the average "air" dose received by survivors in that zone. The zone from 0 to 999 meters, which is designated here as zone A, is a special case, however, since there was heavy mortality near its center. The mean dose for this zone has been computed for the portion of this zone extending from 850 to 999 meters. The majority of leukemia cases in zone A occurred in this latter region (*15*); moreover, two (among five) cases at a distance closer than 850 meters had the type of shielding specified, and in each case it was listed as heavy (*18*). Since the doses for the two cities are slightly different at a given distance from the hypocenter, the average value of these two doses is used without correcting for differences in population size. In this way, a dose of about 1300 rem is arrived at for zone A. For zones B (1000 to 1499 meters) and C (1500 to 1999 meters), the mean doses are approximately 500 rem and 50 rem, respectively. At 2000 meters the dose has fallen to 14 rem and by 2500 meters to less than 5 rem. Since the majority of the population in zone D (from 2000 meters on) was beyond 2500 meters, the average dose is under 5 rem and is thus so low that zone D can be treated as if it were a "control" zone.

The relation of dose, estimated as described in the preceding paragraph, to the incidence of leukemia per year, based on the combined Hiroshima and Nagasaki data, is shown in Table 3. The incidence per year in the "control" zone, D, is subtracted from the incidence in each of the other zones to obtain the "incidence of induced leukemia per year" in these zones. The values of the incidence of induced leukemia are likely to be minimum ones, since, as Lange *et al.* have noted, "some cases of leukemia have undoubtedly been missed and other cases have been omitted because of lack of adequate material to confirm the diagnosis" (*16*). The incidences of induced leukemia in zones A, B, and C have been divided by the respective mean "air" doses in rem, derived in the preceding paragraph, to give estimates for the probability of induced leukemia for these zones. The values for this probability are seen to range from 0.7×10^{-6} to 0.9×10^{-6} per individual per rem per year. These

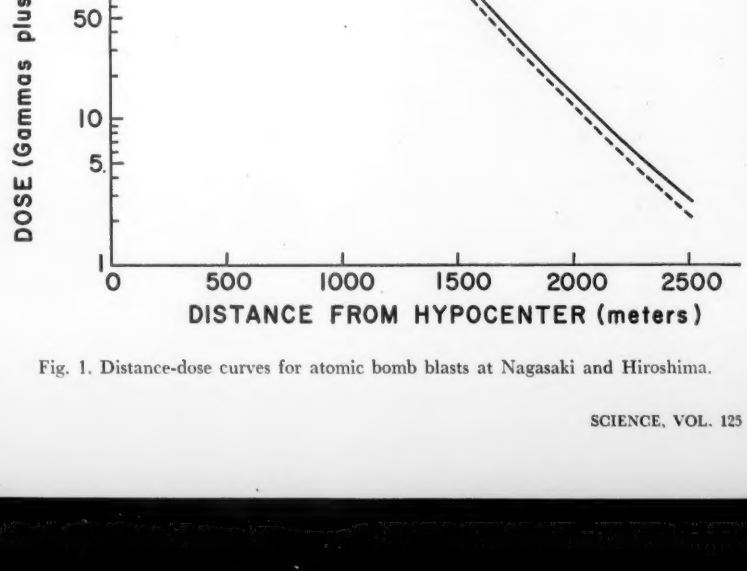


Fig. 1. Distance-dose curves for atomic bomb blasts at Nagasaki and Hiroshima.

are minimum estimates of the probability of induced leukemia, since the survivors were shielded in varying degrees from the "air" doses, calculated in the preceding paragraph. The shielding of survivors has two major components: (i) the body's own shielding of its blood-forming tissues by the surrounding bone and soft tissues; and (ii) external shielding by buildings or other shelters. A shielding factor of 2 is believed to be a conservative one for correcting for both of these components—the true factor might be at least 4 (*23*). The "best" estimate for the probability of induced leukemia from these data is, therefore, taken as approximately twice the aforementioned minimum estimates of 2×10^{-6} per individual per rem per year (of the 7.75-year period). A rough range for this probability is 0.7×10^{-6} to 4×10^{-6}.

Leukemia and Ankylosing Spondylitis

Court Brown and Doll (*24*) and others (*25, 26*) have investigated the incidence of leukemia among patients treated with x-rays for ankylosing spondylitis—a hereditary disease of the spine. Among 11,287 male patients irradiated during the period from 1935 to 1954, inclusive, 37 cases of leukemia were discovered. The average period of follow-up of these patients was "just under five years" (*24*). The distribution of cases by amount of treatment, measured as maximum dose in roentgens (7) to the spinal marrow, is shown in Table 4. A highly significant increase in the incidence of leukemia is apparent among those receiving the heavier treatments.

Court Brown and Doll have estimated the expected incidence of leukemia in a comparable group of unirradiated normal males as 50 cases per million individuals per year. Subtraction of this expected incidence from the observed incidence of leukemia per year in the irradiated patients gives an estimate of the incidence of radiation-induced leukemia per year. This calculation has been carried out for each of the groupings of leukemia cases according to amount of treatment. For each such grouping between 500 and 2750 roentgens, an average maximum dose to the spinal marrow is taken as the mid-point of the dose range (for example, for leukemia cases developing after treatments ranging from 500 to 999 roentgens, 750 roentgens is taken as the average dose). By dividing the calculated incidence of radiation-induced leukemia for each of the four groupings of this kind (column 5, Table 4) by the respective average maximum dose (column 2, Table 4), a set of four minimum estimates of the probability of leukemia per individual per roentgen (to the spinal marrow) per year is obtained.

Table 2. Incidence of leukemia among the combined exposed populations of Hiroshima and Nagasaki by distance from the hypocenter (January 1948–September 1955).

Zone	Distance from hypocenter (m)	Estimated population of exposed survivors (Oct. 1950)	Number of confirmed cases of leukemia	Percentage of leukemia
A	0– 999	1,870	18	0.96
B	1000–1499	13,730	41	0.30
C	1500–1999	23,060	10	0.043
D	2000 and over	156,400	26	0.017

These latter estimates are seen to range from 0.3×10^{-6} to 0.6×10^{-6} per individual per roentgen per year (column 6 of Table 4). It seems likely that the absorbed dose to the entire red-marrow system would be lower than the stated doses to the spinal marrow by a factor of at least 2 or 3. Therefore, it is estimated that the probability of leukemia ranges from about 0.6×10^{-6} to 2×10^{-6} per individual per rad (to the red-marrow system) per year.

Leukemia and Thymic Enlargement

Simpson *et al.* (*6*) have traced a series of 1400 individuals who had been irradiated as infants for an enlarged thymus condition. The average period of follow-up appears to have been about 15 years. As a "control" 1795 unirradiated siblings were also traced. In the irradiated group there were seven confirmed cases of leukemia (and one unconfirmed case), while there was none in the control group. The calculated number of cases of leukemia that would have been expected in a sample of comparable size and age from the general population was 0.6. The difference between this expectation and the observed number of cases (seven) is statistically significant (P less than 0.01).

In the majority of the 1400 infants, the radiation (x-rays) had been more or less restricted to the chest region. It was estimated that the "air" dose to the thymus region was more than 200 roentgens ("the great majority being less than 600 r") in 57 percent of the treated individuals and under 200 roentgens in the remainder. The average absorbed dose to the entire lymphatic system is roughly estimated as 100 to 300 rad. On the basis of these dose estimates, the probability of leukemia ranges from 1×10^{-6} ($6.4/15 \times 1400 \times 300$) to 3×10^{-6} per rad (to the lymphatic system) per individual per year. The number of cases (seven) on which this estimate is based is, of course, small. The 95-percent confidence interval for an observation of seven when the frequency is as low as in the present case lies between 3.3 and 13.2 (*27*). Therefore, the probability of leukemia in the thymic enlargement group may well range from 0.4×10^{-6} to 6×10^{-6} per rad (to the lymphatic system) per individual per year.

Leukemia among Radiologists

March (*28, 29*) and others (*30, 31*) have called attention to the fact that among physicians the percentage of deaths from leukemia is much higher for radiologists than for physicians who are not radiologists. The percentage of deaths that are due to leukemia can be a misleading statistic, however, since it is sensitive to differences in age distribution between the groups of individuals being compared. Such differences are marked in the case of radiologists, on the one hand, and all physicians, on the other, as is discussed later. To assess the

Table 3. Incidence of leukemia per year among the combined exposed populations of Hiroshima and Nagasaki (January 1948 to September 1955) in relation to dose of radiation (gammas plus neutrons).

Zone	Average maximum dose (rem)	Incidence of leukemia per million per year	Incidence of radiation-induced leukemia per million per year	Probability of leukemia per individual per rem per year
A	1300	1200	1179	0.9×10^{-6}
B	500	390	369	0.7×10^{-6}
C	50	56	35	0.7×10^{-6}
D	5	21		

Table 4. Incidence of leukemia among ankylosing spondylitis patients receiving different doses of radiation (x-rays). Data from Court Brown and Doll (*24*).

Maximum dose to spinal marrow (r)	Estimated average maximum dose (r)	Number of males developing leukemia	Crude incidence per million males per year	Incidence of radiation-induced leukemia per million males per year	Probability of leukemia per individual per r (to spinal marrow) per year
0			50		
Under 500		2	220	170	
500– 999	750	8	410	360	0.5×10^{-6}
1000–1499	1250	8	420	370	0.3×10^{-6}
1500–1999	1750	8	1130	1080	0.6×10^{-6}
2000–2749	2375	6	1300	1250	0.5×10^{-6}
2750 or more		5	1760		

radiation factor in the leukemia among radiologists, it first becomes necessary to estimate (i) the death rate from leukemia among radiologists (the number of deaths per total number of living radiologists), and (ii) the expected death rate from leukemia among radiologists if they had received no occupational exposure to radiation.

The study of mortality among medical specialists by Dublin and Spiegelman (*32*) has been used here as a guide in computing the afore-mentioned rates and as source of data for the years 1938 to 1942, inclusive. The latter data and additional data for the years 1943 to 1952, inclusive, are summarized in Table 5. The term *radiologist* is restricted here, following Dublin and Spiegelman, to those physicians who were listed in editions of the *American Medical Directory* (*33*) as limiting their practice to radiology (and roentgenology). Since only deaths occurring at ages 35 to 74 years, inclusive, were included in the mortality study for 1938–42, the same practice is adopted here for the supplementary 10-year period.

In order to estimate the mean annual population of radiologists at ages 35 to 74 years, during the entire 15-year period from 1938 to 1952, the age distribution of radiologists is required. This age distribution for the year 1940 was computed by Dublin and Spiegelman from the 1940 edition of the *American Medical Directory* and is shown in Table 6. The age distribution for a similar group of radiologists in 1950, also shown in Table 6, has been computed (*34*) by reference to the 1950 edition of this directory. The 1940 age distribution was based on a total of 1595 radiologists of whom 1451.5 (91.0 percent) can be inferred to have been at ages 35 to 74 years, inclusive (*32*). The 1950 age distribution was based on a total of 2443 radiologists of whom 2250 (92.1 percent) are calculated to have been at ages 35 to 74 years, inclusive, as of 1 July 1950. The mean number of radiologists (at ages 35 to 74) per year from 1938 to 1952, inclusive, is roughly approximated as 1850.7, which is the average of the number of such radiologists in 1940 and the corresponding number in 1950.

Deaths from leukemia occurring at ages 35 to 74 years, inclusive, among radiologists have been located in several ways with the results shown in Table 5. For the period from 1938 to 1942, inclusive, five such deaths are recorded by Dublin and Spiegelman. For the period from 1943 to 1948, inclusive, the carefully documented studies of March (*28*, *29*) record eight such deaths. For the remaining 4-year period from 1949 to 1952, inclusive, four additional deaths from leukemia have been located by reference to death notices in a medical journal (*35*). Thus, a minimum of 17 deaths from leukemia has been located among radiologists who died between the ages of 35 and 74 years during the 15-year period from 1938 to 1952. The upper and lower 95-percent confidence limits for this observation of 17 deaths are 25.5 and 10.8 deaths, respectively (*27*). Thus, a likely range of values for the average death rate from leukemia among radiologists at ages 35 to 74 years is 390 ($10.8/15 \times 1850.7$) to 920 ($25.5/15 \times 1850.7$) deaths per million per year, and the "best" estimate is 610 ($17/15 \times 1850.7$) deaths per million per year (of the 1938–52 period).

The expected death rate from leukemia among radiologists, if they had received no occupational exposure to radiation, is estimated by first calculating the death rate they would have experienced if subject to U.S. white male death rates from leukemia. This calculation has been made for a 3-year period from 1939 to 1941 by first computing (*36*) the mean annual age-specific U.S. white male death rates from leukemia (Table 7) and then applying them to the 1940 age distribution of radiologists (Table 6), restricting the computation to the 35–74-year age interval. The resultant expected death rate for the latter age interval is 63 deaths per million per year.

The same type of calculation has been carried out for a 3-year period from 1949 to 1951 by computing (*36*) the appropriate age-specific death rates for that period (Table 7) and applying them to the 1950 age distribution of radiologists. The resultant expected death rate is 88 deaths per million per year.

The average of the rates for the 1939–41 and 1949–51 periods is 76 deaths per million per year. The latter rate should roughly approximate the mean annual death rate from leukemia which radiologists would have experienced during the 1938–52 period if they had been subject to U.S. white male death rates for this disease. The observed death rate for this period was 610 deaths per million per year (Table 5), which is 8 times the expected rate, just calculated.

It is possible, however, that reasons other than radiation exposure may account for the high death rate from leukemia among radiologists. For example, leukemia might be more likely to be diagnosed among radiologists than among the group of all U.S. white males. To correct for such possibilities as this, the expected death rate of 76 deaths from leukemia per million per year, calculated in the preceding paragraph, is multiplied by a correction factor of 1.6.

Table 5. Deaths and death rates from leukemia among radiologists, at ages 35 to 74 years, by 5-year periods from 1938 to 1952, inclusive.

Period	Estimated number of radiologists at mid-point of period	Number of deaths from leukemia	Observed death rates per million per year	Expected death rates per million per year	Incidence of radiation-induced deaths per million per year
1938–42	1451.5	5	690	101	589
1943–47	(1850.7)*	6	650	(121)*	429
1948–52	2250.0	6	530	141	389
(1938–52)	(1850.7)*	17	610	(121)*	489

* The arithmetic average of the values for the 1938–42 and 1948–52 periods.

This factor is the ratio of the observed number of deaths from leukemia among physicians who were nonradiologists to the expected number of deaths calculated on the assumption that such physicians were subject to U.S. white male age-specific death rates for leukemia.

This factor of 1.6 has been inferred from data for the 1938–42 period given by Dublin and Spiegelman (*32*) and is applied throughout the entire 15-year period from 1938 to 1952 to give the expected death rates shown in Table 5. It is a conservative factor in the sense that it is possible that the increased death rate from leukemia among physicians who are nonradiologists is partly due to exposure of some of them to ionizing radiation (*31*). Thus, 121 (1.6×75.5) deaths per million per year is probably a conservative estimate of the expected death rate from leukemia among radiologists in the 1938–52 period, if they had received no exposure to radiation.

The expected death rate from leukemia, just calculated, would be expected to yield 3.4 ($15 \times 1850.7 \times 121 \times 10^{-6}$) deaths among radiologists during the 1938–52 period. It is appropriate at this point to compare this with the observed number—namely, 17 deaths (Table 5). The probability of observing 17 or more when the expected number is 3.4 is readily obtained from the Poisson distribution and is found to be less than 1×10^{-6}. Hence, the observed value exceeds the expected value at a statistically highly significant level.

The difference between the expected death rate from leukemia calculated on the assumption of no occupational exposure to radiation and the observed death rate is designated the "incidence of radiation-induced leukemia," L. For a stationary population chronically irradiated at a constant dose rate, D, the incidence, L, can be approximated if it is assumed that the probability of leukemia per rad of accumulated dose per year, P_L, is a constant for all age groups in the population and for all values of the accumulated dose. On these assumptions, a stationary population exposed for a mean number of years, E, to the dose rate, D, will have an incidence of radiation-induced leukemia that can be expressed as follows:

$$L\ (=)\ (D) \cdot (E) \cdot (P_L)$$

To estimate the value of E, it is assumed that occupational exposure of radiologists starts at age 25 and ends at age 65. The value of E for individuals who were at ages 35 to 74 in 1940 can then be approximated from the age distribution of radiologists for that year (Table 6) and is found to be 24.7 years. The corresponding value of E approximated from the 1950 distribution (Table 6) is 24.1 years. The average of these two values, 24.4 years, is used as the value of E for the population of radiologists who were at ages 35 to 74 years in the 1938–52 period. The "best" estimate of L is 489 deaths per million per year, (Table 5), and a likely range of values for L is 270 to 800 deaths per million per year, based on the 95-percent confidence limits for the observed death rate of 610 deaths per million per year. For reasons discussed later, the value of D is estimated to lie between 3 and 30 rad per year.

Table 6. Age distribution of radiologists, in 1940 (*32*) and 1950.

Age	Percentage distribution as of	
	1940	1950 (1 July)
Under 35	8.3	6.1
35–44	31.3	38.9
45–54	33.8	26.6
55–64	19.8	18.7
65–74	6.1	7.9
75 and over	0.7	1.8
Total	100.0	100.0

The "best" estimate for the range of values of P_L is then given by the expression

$$P_L\ \text{(likely range)} = \frac{489}{24.4 \times (3 \text{ to } 30)} = (0.7 \text{ to } 7) \times 10^{-6}$$

per individual per rad per year

A broader range, based on the confidence limits for L, is $(0.4 \text{ to } 11) \times 10^{-6}$ per individual per rad per year.

Since the dose rate, D, in the foregoing discussion, represents the average absorbed dose rate to the leucocyte-producing system, it is likely to be lower by at least a factor of 2 than the "air" dose rate to which radiologists were exposed. The recommended maximum dose rate (in air) for such workers was set at 0.2 roentgen per day in 1931 by the U.S. National Committee on Radiological Protection; this rate was reduced to 0.1 roentgen per day in 1936 and to 0.05 roentgen per day in 1949. Although some radiologists may well have exceeded the recommended dose rates, it seems unlikely that the average dose rate for all radiologists in the group under consideration would have exceeded the permissible limits set in 1931. Thus 30 rad per year has been taken as an upper limit for the absorbed dose to the leucocyte-producing system. The lower limit for D has arbitrarily been taken as one-tenth of this or 3 rad per year.

This estimate that D might be much less than 30 rad per year is somewhat at variance with the following conclusions from a recent study of longevity among radiologists (*37*). "In comparison with non-exposed physicians the shortening of life of radiologists is 5.2 years or 11% of the adult life span (after 20 years). If extrapolation from the animal data . . . is permissible, this would be expected to result from chronic whole body exposure to about 1.5 LD_{50} dose or possibly 1000 roentgens. Although this exposure was partial body and possibly less effective, it seems unlikely that the equivalent whole body exposures differed from the above value by a factor greater than 2 or 3. Consequently it appears that, within these limits at least, extrapolation from short-lived animals to man may be made with some confidence on the basis of per cent life-shortening per unit dose."

The shortening of life by 5.2 years just cited is based on the observation that during the period 1930–54 the difference between the mean age at death of physicians estimated to have had "no known contact with radiation" and the mean age at death of radiologists was 5.2 years (*37*). It can be calculated (*38*), however, that a difference of at least 6 years would be expected in this case solely as the result of differences in age distribution (as of 1940 or 1950) between radiologists, on the one hand, and all physicians, on the other. That is, radiologists may have a slightly longer life-span than physicians as a whole. Moreover, for the 1938–42 period, Dublin and Spiegelman showed that, after appropriate adjustment for differences in age distribution, the total death rate from all causes was lower for radiologists than it was for all physicians combined; however, this rate was slightly higher for radiologists than it was for all specialists combined. Thus, either a chronic whole-body exposure of 1000 roentgens does not have a marked effect on longevity or, more probably, radiologists have *averaged* much less than this as a life-time absorbed dose.

Discussion

Table 8 summarizes the various estimates of the probability of leukemia derived from the four sets of data reviewed here. For acute whole-body irradiation, the "best" estimate of this probability will be taken as 2×10^{-6} per individual per rad per year. This value is based on the studies of leukemia among

Table 7. United States white male death rates from leukemia per million per year.

Age	Period	
	1939–41	1949–51
25–34	18	26
35–44	29	34
45–54	55	68
55–64	104	149
65–74	154	276
75+	181	385

survivors of atomic bomb radiation. For acute partial-body irradiation, the available data are conveniently discussed in terms of a probability of leukemia "of bone-marrow origin" (ankylosing spondylitis patients) or a probability of leukemia "of lymphatic origin" (thymic enlargement patients).

As has already been noted, granulocytic and lymphocytic leukemias may have bone-marrow and lymphatic origins, respectively. Since these two types of leukemia constitute the majority of all leukemias and occur in proportions which are, for present purposes, roughly equal, it is assumed that the "best" estimate of the probability of leukemia of bone-marrow origin is one-half of that for all leukemia, or 1×10^{-6} per individual per rad to the red marrow per year. Similarly, the "best" estimate of the probability of leukemia of lymphatic origin is taken as 1×10^{-6} per individual per rad to the lymphatic system per year.

These estimates fall within the range of values calculated for either the ankylosing spondylitis patients or the thymic enlargement patients. Moreover, there is some evidence that leukemia following irradiation of the spinal marrow is primarily granulocytic (*26*). Whether lymphocytic leukemia predominates in the thymic enlargement series (*6*) is uncertain on two grounds: (i) it is difficult to differentiate granulocytic and lymphocytic types in infants and children; and (ii) some irradiation of bone marrow would, in any case, be expected in this series of patients (*39*). Finally, the "best" estimate of the probability of leukemia following chronic whole-body irradiation is taken as identical with that for acute whole-body irradiation—namely, 2×10^{-6} per individual per rad (of accumulated dose) per year. This value is seen to be close to the lower limit of the range of values deduced for radiologists.

Simpson *et al.* (*6*) and Court Brown and Doll (*24*) point out that their studies lack a control in the form of an unirradiated series of patients. Thus, the possibility is not excluded that thymic enlargement and ankylosing spondylitis predispose toward leukemia. However, a comparison of the various estimated ranges for the probability of leukemia (Table 8) suggests that patients with the afore-mentioned conditions are no more prone to develop leukemia than are radiologists or the Japanese survivors.

Presently available determinations of the incidence of induced leukemia per year are based on average follow-up periods that are comparatively short in terms of the normal human life-span. Thus, the probability of leukemia per individual per rad per year may not be constant for an indefinite period beyond the initial time of irradiation. By choosing the lower limit for the probability of leukemia at about 0.7×10^{-6} per individual per rad per year, it is felt that adequate account is taken of the possibility that the incidence of leukemia per year following an acute dose of radiation may, as some have suggested on the basis of the data from Hiroshima (*37*), reach a peak followed by a steady decline. It is noteworthy, however, that Court Brown and Doll have concluded, from an analysis of 108 cases of leukemia among the exposed populations of Hiroshima and Nagasaki, that "the data provide no evidence of a sharp peak in incidence at any particular period after the explosion nor any clear indication that the incidence had yet begun to diminish by the end of the ninth year" (*40*).

The probability of leukemia per individual per rad per year is nearly constant over a rather wide range of doses in the case of the Japanese survivors (Table 3) and in the case of ankylosing spondylitis patients (Table 4). This is presumptive evidence that the relationship between incidence of induced leukemia and dose of radiation is either linear or approximately linear. A striking feature of the Japanese data shown in Table 2 is that the incidence of leukemia in zone C—the zone with a calculated average "air" dose of 50 rem—is significantly higher than in zone D, the "control" zone ($P = 0.02$, by the Chi-square test). Thus, these data provide no evidence for a threshold dose for the induction of leukemia. Moreover, chronic irradiation at a relatively low dose rate (perhaps 0.1 rad per day or less) appears to induce leukemia in radiologists at a rate per rad which is comparable to that observed for the Japanese survivors. This finding also fails to support the concept of a threshold dose below which leukemia will not develop.

A linear relationship between the incidence of leukemia and dose of radiation, which is suggested by the available data for man, may have its explanation in a somatic mutation hypothesis (*41*). Thus, radiation-induced leukemia may result from a somatic gene mutation, presumably occurring in one of the precursor cells destined to give rise to mature leucocytes. Such a mutation might cause the cell, or its descendants, to acquire an unregulated growth habit, or to release, or to respond to, viruslike or hormonal agents—to mention only a few of many possibilities. Thus, the somatic mutation hypothesis and other hypotheses for the origin of radiation-induced malignancies (*42*) are by no means mutually exclusive. Gene mutation has long been known to show a linear relationship with respect to dose of ionizing radiation from studies with *Drosophila*. This linearity has been extended by Spencer and Stern (*43*) to doses of 50 and 25 roentgens. Gene mutation is also known to be directly proportional to the accumulated dose of radiation, even when the radiation is chronically administered at a relatively low dose rate, as in the studies of Uphoff and Stern (*44*).

The concept of somatic mutation is also helpful in attempting to explain the long period of time which sometimes intervenes between irradiation and onset of leukemia. Thus, it may be that some of the precursor cells of leucocytes lie quiescent for years before they are brought into leucocyte production. A somatic mutation in such a cell might, therefore, be long delayed in producing its effect.

In leukemia of "spontaneous" origin, there is also likely to be a somatic mutation component which would be attributable to "spontaneous" mutation in the somatic cells. In addition, there is likely to be a "hereditary" component in spontaneous leukemia—that is, the presence of defective genes (dominant or recessive) which are transmitted through the germ line and which result in, or predispose toward the development of, leukemia. It is well known from the work of MacDowell and associates (*45*) that the pronounced differences among certain strains of mice in susceptibility to leukemia have a genetic basis. In man, there is evidence for familial factors in leukemia from the work of Videbaek (*46*) and others, but the type of inheritance involved is not clear (*47*). It should be noted that cases of leukemia which arise somatically—for example, those which are radiation-induced—will tend to obscure the analysis of the hereditary component in leukemia (*48*).

It is likely that there will be individual differences in susceptibility to radiation-induced leukemia as well as to "spontaneous" leukemia. The indication of a linear relationship between dose of radiation and incidence of leukemia implies that there are some individuals in whom a single radiation-induced event (perhaps a gene mutation) suffices to produce leukemia. There may, however, be other individuals in whom two or more such events would be required before leukemia would be manifested. Thus, the values of the probability of leukemia per individual per rad per year that have been derived here apply to the "average" individual in a given population, but do not necessarily apply equally to each and every individual in that population.

Spontaneous Leukemia and Natural Background Radiation

The possibility that a portion of the "spontaneous" incidence of leukemia may be due to radiation from natural background sources is briefly considered. For this purpose, the same type of approximation procedures employed for assessing radiation-induced leukemia

among radiologists is applied to the data of MacMahon and Clark on the spontaneous incidence of leukemia in the white population in the borough of Brooklyn (Table 1). Thus, the incidence of leukemia, L_B, that would be attributable to irradiation of that population from natural background sources can be approximated by assuming that it is a product of the following three quantities: (i) a constant dose rate, D_n, from all natural background sources; (ii) the mean age, E_B, of the Brooklyn population, which is equivalent to the mean number of years exposed to D_n; and (iii) the probability of leukemia, P_L, per individual per rad per year. The value of D_n is not known but probably is in the range of 0.1 to 0.2 rad per year (*49*). The value of E_B can be readily approximated from the age distribution (Table 1) of the Brooklyn population and is about 33.7 years. The value of P_L is chosen as the "best" estimate from the afore-described radiation studies, namely 2×10^{-6} per individual per rad per year. Thus, L_B can be estimated as 7 to 13 cases per million per year. The observed total spontaneous incidence in this study was 64.4 cases per million per year (*13*). Thus, possibly 10 to 20 percent of the "spontaneous" incidence of leukemia in this Brooklyn population is attributable to ionizing radiation from natural background sources.

A maximum value for the probability of radiation-induced leukemia may also be inferred from the Brooklyn data. The calculation of such a value is based on the incidence of acute leukemia, since in this form of the disease the time of onset and time of diagnosis probably nearly coincide, while in chronic leukemia some years may elapse between these two times. The observed incidence of acute leukemia has a minimum value of 12 per million per year which occurs in the 20–29 age group (Table 1). By assuming that individuals in that age group had an average accumulated dose of not less than 2.5 rad (0.1 rad per year for 25 years) and by further assuming, as an artifice, that all of the acute leukemia in that age group was due to radiation, the probability of acute leukemia may be estimated to have an upper limit of 5×10^{-6} ($12 \times 10^{-6}/2.5$) per individual per rad per year. Since the over-all ratio of acute to chronic forms was about 1/1 in the Brooklyn data, it may be inferred that the maximum value, or upper limit (Table 8), of the probability of leukemia (acute and chronic) is about 10×10^{-6} per individual per rad per year.

Application to Radiostrontium Exposure

The foregoing estimates of the probability of radiation-induced leukemia have been attempted in order to have some basis for assessing direct effects of ionizing radiations on human populations. An example of the application of these estimates to a man-made radiation exposure—namely, that from radiostrontium (Sr^{89} and Sr^{90})—is briefly discussed (*50*).

The maximum permissible concentration (MPC) of Sr^{90} has been set at 1 microcurie for the total body *for workers with radioisotopes* (*51*). A level of 1 microcurie of Sr^{90} per 1000 grams of calcium (the mass of calcium in the average adult individual) has been designated as 1 "MPC" unit of Sr^{90} (*52*). Various estimates are at hand for the level of radiostrontium that is being accumulated in the human body as the result of past testing of atomic weapons (*53*). The present discussion is restricted to examination of the following recent suggestion for a permissible level (presumably of Sr^{90}) *for the population at large* (*54*). "There seems no reason to hesitate to allow a universal human strontium (very similar chemically to calcium) burden of 1/10 of the permissible, yielding 20 rep in a lifetime, since this dose falls close to the range of values for natural radiation background. Visible changes in the skeleton have been reported only after hundreds of reps were accumulated and tumors only after 1500 or more."

A body level of 0.1 MPC is expected to irradiate skeletal tissue at a dose rate of about 0.25 rad per year, on the assumption of uniform distribution of Sr^{90} throughout that tissue. Because of the limited range in tissue of the beta particles emitted in the decay of Sr^{90} and of its daughter element, Y^{90}, the leucocyte-producing cells may receive somewhat less than this dose rate, depending on the exact location of such cells with respect to the surrounding calcium of the bone. This reduction factor, of perhaps 2, tends to be offset by the fact that ingested Sr^{90} is not uniformly distributed throughout the skeletal tissue but appears instead to be concentrated in regions more actively concerned with red-marrow formation (*55*). The dose rate to the leucocyte-producing cells is estimated as 0.1 to 0.2 rad per year for a body level of 0.1 MPC of Sr^{90}. This irradiation will be largely restricted to the skeletal tissue, since (i) the radiation from the decay of Sr^{90} is exclusively of the beta type and (ii) 70 percent of the Sr in the body is estimated to lie in the skeletal tissue (*51*). Hence, leukemia induced by Sr^{90} would be expected to be largely of bone-marrow origin (*56*).

The problem of assessing the incidence of Sr^{90}-induced leukemia from a constantly maintained level of Sr^{90} is essentially identical with that dealt with here for determining the component of the spontaneous incidence of leukemia owing to natural background radiation. Thus, the incidence of Sr^{90}-induced leukemia in a stationary population maintaining a constant level of 0.1 MPC of Sr^{90} is con-

Table 8. Summary of the estimates of the probability of radiation-induced leukemia per individual per rad per year.

Source of estimate	Type of radiation	Region irradiated	Types of leukemia produced	Probability of leukemia of specified type per individual per rad (or rem) to region irradiated per year		
				Estimated range		"Best" estimate
				Lower limit	Upper limit	
Atom-bomb survivors	Gamma rays plus neutrons	Whole body	All	0.7×10^{-6}	3×10^{-6}	2×10^{-6}
Ankylosing spondylitis patients	X-rays	Spine	Granulocytic (only?)	0.6×10^{-6}	2×10^{-6}	1×10^{-6}
Thymic enlargement patients	X-rays	Chest	Lymphocytic (only?)	0.4×10^{-6}	6×10^{-6}	1×10^{-6}
Radiologists	X-rays, radium, etc.	Partial to whole body	All (?)	0.4×10^{-6}	11×10^{-6}	2×10^{-6}
Spontaneous incidence of leukemia (Brooklyn, N.Y.)	All natural background sources	Whole body	All (?)		10×10^{-6}	2×10^{-6}

sidered to be the product of (i) a dose rate of 0.1 to 0.2 rad per year to red bone marrow; (ii) a mean age for the stationary population of 31.7 years, which is that expected from the age distribution of the total U.S. white population as of 1 July 1955 (*57*); and (iii) a probability of leukemia of bone marrow origin of 1×10^{-6} per individual per rad to bone marrow per year. This computation gives an incidence of three to six cases of Sr^{90}-induced leukemia per million per year. For a population of 1.6×10^8 individuals, the current population of the U.S., the expected number of cases of leukemia induced by a constantly maintained level of 0.1 MPC of Sr^{90} would thus be about 500 to 1000 per year. The range for this estimate is a factor of about 3, giving 150 to 3000 cases per year. Currently (1954), there are about 10,500 deaths from leukemia per year in the U.S. population (*10*). Thus, if Sr^{90} induces leukemia of bone-marrow origin at the same rate (per rad) as x-rays and radiations from atomic bombs, then a constantly maintained level of 0.1 MPC of Sr^{90} would be expected to increase the present incidence of leukemia (in the United States) by about 5 to 10 percent.

Summary

Leukemia in man can be induced by ionizing radiations and also occurs spontaneously. For the "average" individual in a population, the probability of developing radiation-induced leukemia is estimated to be 2×10^{-6} per rad (unit of absorbed dose of radiation) per year. The available data from four independent sources make it likely that this estimate is valid within a factor of about 3, giving a range from 0.7×10^{-6} to 6×10^{-6} per rad per year. It is pointed out that 10 to 20 percent of the spontaneous incidence of leukemia (Brooklyn, 1943–52) may result from radiation from natural background sources. It is estimated that a 5- to 10-percent increase in the current spontaneous incidence of leukemia would occur if the population were to reach and maintain a body level of Sr^{90} amounting to one-tenth of the "maximum permissible concentration."

References and Notes

1. For example, H. J. Muller, *Am. J. Human Genet.* 2, 111 (1950).
2. *The Biological Effects of Atomic Radiations*, Summary rept. (Natl. Acad. Sci. U.S., Washington, D.C., 1956).
3. *The Hazards to Man of Nuclear and Allied Radiations*. Rept. of the Medical Research Council (Brit.) (H.M. Stationery Office, London, 1956).
4. For example, R. J. Hasterlik in *Proc. Intern. Conf. on the Peaceful Uses of Atomic Energy* (United Nations, New York, 1956), vol. 11, p. 148.
5. D. E. Clark, *ibid.* p. 146.
6. C. L. Simpson, L. H. Hempelmann, L. M. Fuller, *Radiology* 64, 840 (1955).
7. For the sake of consistency, the "rad," the unit of absorbed dose (100 ergs per gram) is adopted. When the relative biological effectiveness (RBE) is not necessarily unity, as in the case of neutrons, the "rem" (roentgen-equivalent-man) is used (rem = rad × RBE). The factor for converting the "r," or "roentgen," to the rad varies with the type of material and energy of radiation [see, for example, F. Ellis, *Brit. J. Radiol.* 29, 367 (1956)]; since this conversion factor is usually nearly unity (or, in the case of bone marrow, is not easily estimated), the rad is taken as equivalent to the r, for the purposes of this article. The "rep" (roentgen-equivalent-physical) is another unit of absorbed dose (93 ergs per gram of tissue) which is gradually being replaced by the rad.
8. M. S. Sacks and I. Seeman, *Blood* 2, 1 (1947).
9. A. G. Gilliam, *ibid.* 8, 693 (1953).
10. *Vital Statistics—Special Reports*. vol. 44, No. 12 (Natl. Office of Vital Statistics, Washington, D.C., 1956).
11. *Ibid.* vol. 43, No. 11 (1956).
12. W. Damashek and F. W. Gunz, *J. Am. Med. Assoc.* 163, 838 (1957).
13. B. MacMahon and D. Clark, *Blood* 11, 871 (1956).
14. I am indebted to Brian MacMahon for providing unpublished data used in preparing Table 1.
15. J. H. Folley, W. Borges, T. Yamawaki, *Am. J. Med.* 13, 311 (1952).
16. R. D. Lange, W. C. Moloney, T. Yamawaki, *Blood* 9, 574 (1954).
17. W. C. Moloney and M. A. Kastenbaum, *Science* 121, 308 (1955).
18. I had access to an unpublished, detailed listing of leukemia cases up to Sept. 1955, provided by the Atomic Bomb Casualty Commission, through the courtesy of R. W. Miller. The number of cases of leukemia shown in Table 2 is compiled from this source.
19. Studies of children irradiated *in utero* [A. Stewart, J. Webb, D. Giles, D. Hewitt, *Lancet* 271, 447 (1956)] or in early infancy (*6*) may help to refine estimates of the probability of radiation-induced leukemia in these age groups.
20. J. V. Neel and W. J. Schull, *The Effect of Exposure to the Atomic Bombs on Pregnancy Termination in Hiroshima and Nagasaki*. Publ. 461 (Natl. Acad. Sci. US., Washington, D.C., 1956).
21. G. Dunning, in an address before the Wash. Acad. Sci., 15 Nov. 1956 (U.S. Atomic Energy Commission, Washington, D.C., 1956).
22. A. C. Upton *et al.*, *Proc. Soc. Exptl. Biol. Med.* 92, 436 (1956).
23. A detailed discussion of many aspects of the problem of estimating doses received by the survivors is given by R. R. Wilson, *Radiation Research* 4, 349 (1956).
24. W. M. Court Brown and R. Doll, reference *3*, appendix B, p. 87.
25. W. M. Court Brown and J. D. Abbat, *Lancet* 268, 1283 (1955).
26. H. van Swaay, *ibid.* 269, 225 (1955).
27. F. Garwood, *Biometrika* 28, 437 (1936).
28. H. March, *Radiology* 43, 275 (1944).
29. ———, *Am. J. Med. Sci.* 220, 282 (1950).
30. H. Ulrich, *New Engl. J. Med.* 234, 45 (1946).
31. S. Warren, *J. Am. Med. Assoc.* 162, 464 (1956).
32. L. I. Dublin and M. Spiegelman, *ibid.* 137, 1519 (1948).
33. *American Medical Directory* (Am. Med. Assoc., Chicago, Ill.).
34. The 1950 distribution is based only on radiologists listed in the section of the 1950 *American Medical Directory* devoted to membership in radiological societies. Each name in that list was looked up in the main body of the directory to determine year of birth and type of specialization. Only those listed as "R*" (an asterisk signifies that practice is limited to radiology) and resident in the continental U.S. were used in compiling the final age distribution. This procedure therefore fails to include radiologists who were nonmembers of radiological societies; however, this deficiency has been taken into account by establishing that the 12 deaths from leukemia from 1943–52, inclusive, were in fact radiologists whose names were listed in the section of the 1940 or 1950 directory devoted to membership in radiological societies. (I am indebted to Alethea Miller, Janet Chaitkin, and Ioan Lewis for assistance in compiling the 1950 age distribution.)
35. The procedure was to obtain a list of deaths of members of one of the leading radiological societies and to search for the cause of death in the death notices of the *Journal of the American Medical Association*. In the period 1949–52, inclusive, only some 70 percent of all such deaths were found to have a cause of death listed. In order to have a conservative estimate of the incidence of leukemia, no correction for this defect is attempted. The four deaths from leukemia in the 1949–52 period have the following volume and page locations in the afore-mentioned journal: 144, 407; 147, 1065; 148, 218; 151, 488.
36. Death rates from leukemia for the years 1939–41 have been obtained from reference *11* and computed for the 1949–51 period from *Vital Statistics of the United States* (Federal Security Agency, Washington, D.C., 1949–51). Sources for the living population were *Current Population Repts., Series P-25*, No. 98 (1954); No. 114 (1955); No. 121 (1955). (U.S. Bur. of the Census, Washington, D.C.)
37. *Pathologic Effects of Atomic Radiation*. Publ. 452 (Natl. Acad. Sci. U.S., Washington, D.C., 1956).
38. The computation involved applying the age distribution of radiologists for 1940 and 1950 (Table 6) to the age-specific death rates for physicians for 1938–42 and 1949–51, respectively. Death rates for the former period are given by L. I. Dublin and M. Spiegelman [*J. Am. Med. Assoc.* 134, 1211 (1947)] and for the latter period by F. G. Dickinson and L. W. Martin [*J. Am. Med. Assoc.* 162, 1462 (1956)].
39. These uncertainties about the type of leukemia in the thymic enlargement series have been pointed out by C. L. Simpson (personal communication).
40. W. M. Court Brown and R. Doll, quoted from reference *3*, appendix A, p. 84.
41. H. J. Muller, *Science* 66, 84 (1927).
42. See, for example, discussions by J. Furth, *Blood* 6, 964 (1951).
43. W. P. Spencer and C. Stern, *Genetics* 33, 43 (1948).
44. D. E. Uphoff and C. Stern, *Science* 109, 609 (1949).
45. E. C. MacDowell, J. S. Potter, M. J. Taylor, *Cancer Research* 5, 65 (1945).
46. A. Videbaek, *Heredity in Human Leukemia and Its Relation to Cancer*. (Munksgaard, Copenhagen, Denmark, 1947).
47. See discussions by J. V. Neel and W. J. Schull, *Human Heredity* (Univ. of Chicago Press, Chicago, Ill., 1954).
48. To illustrate, a check of the case histories in Videbaek's study (*46*) of heredity in leukemia reveals that among the female probands who were at ages 40 to 59, inclusive, at the time of diagnosis of leukemia, six (12 percent) were reported to have received castration doses of x-rays to the ovaries prior to the diagnosis of leukemia.
49. F. W. Spiers, *Brit. J. Radiol.* 29, 409 (1956).
50. Only the longer-lived isotope, Sr^{90} (half-life, 28 years) is considered in the discussion which follows.
51. *National Bureau of Standards Handbook 52*. (Supt. of Documents, U.S. Govt. Printing Office, Washington, D.C., 1953.)
52. W. F. Libby, *Proc. Natl. Acad. Sci. U.S.* 42, 365 (1956).
53. ———, *ibid.* 42, 945 (1956); and M. Eisenbud, in an address before the Wash. Acad. Sci., 15 Nov. 1956 (U.S. Atomic Energy Comm., Washington, D.C., 1956).
54. Quoted from reference *37*, p. 7.
55. C. L. Comar and R. H. Wasserman, in *Progress in Nuclear Energy, Ser. VI* (Pergamon, London, 1956); and J. L. Kulp, W. R. Eckelmann, A. R. Sculert, *Science* 125, 219 (1957).
56. Evidence suggesting that Sr^{90} may produce leukemia in mice has been reported by S. Watanabe, *Acta Haematol. Jap.* 18, 508 (1955).
57. *Current Population Repts., Series P-25*, No. 121 (U.S. Bur. of the Census, Washington, D.C., 1955).

Saldanha Man and His Culture

William L. Straus, Jr.

Enough evidence is now available to permit evaluation of the fossil human skullcap and fragment of lower jaw that constitute the creature known as "Saldanha Man." This South African specimen, found in 1953 by Keith Jolly and Ronald Singer, is particularly interesting because of its association with a variety of fossil vertebrates and stone tools. The site of discovery is located about 10 miles from Hopefield, a village near Saldanha Bay, some 90 miles north of Cape Town.

Despite certain differences in details, the Saldanha skullcap, in general, strongly resembles that of the famous Rhodesian skull, which was discovered in a cave at Broken Hill, Northern Rhodesia, in 1921 (*1–3*). As Singer (*1*) has shown, the two skullcaps are strikingly similar in both general outline and measurements. The brow-ridges of the Saldanha skull are comparatively huge, approximating but not equaling the truly enormous ones of Rhodesian Man; the shape and curvature of these structures differ, however, in the two skulls (*1*). The contours of the respective frontal bones and, hence, the shapes of the foreheads are practically identical.

Drennan (*3*) believes that the Saldanha mandibular fragment suggests a "typically Neanderthaloid" lower jaw which would be quite "out of harmony" with the Rhodesian skull (no part of the Rhodesian lower jaw was recovered, but the upper jaw is complete); rather, he regards it as closely resembling the corresponding part of the famous but enigmatic Heidelberg jaw. The Saldanha and Rhodesian mandibles were, therefore, in Drennan's opinion, quite different in morphology. Possibly such a conclusion is legitimate. However, conclusions based on bits of mandibles should be taken *cum grano salis*. As for expecting inevitable "harmony" between mandible and cranium, it may be noted that nature has produced some strange combinations. Relevant to this matter is the recent observation of Hutchinson (*4*) that Oldfield Thomas, a distinguished mammalogist, epigrammatized that whereas God made the cranium, the devil made the mandible.

The nuchal plane of the Saldanha skull is largely lacking. Drennan (*2*) thinks that it must have inclined backward as in Neanderthal skulls, an arrangement that he regards as indicative of a crouching posture. In the opinion of Singer (*1*), however, there is little reason for believing that the Saldanha nuchal plane differed markedly from that of the Rhodesian skull, which is disposed essentially horizontally, as in modern man. It may be added that, whatever the slope of his nuchal plane, it now appears that there is no reason to suppose that the posture of Neanderthal Man differed fundamentally from that of present-day man.

Endocranial casts are notoriously unreliable for determining slight differences in cerebral status. Yet Drennan (*3*) concludes that a comparison of the Rhodesian and Saldanha casts "substantiates a degree of cerebral inferiority" in the latter; and he holds this opinion despite the presence of an "ultra-gorilline" and supposedly primitive condition in the obelionic region of the Rhodesian endocranial cast, which is lacking in the Saldanha cast. One has only to recall the supposed evidences of primitive or inferior features originally noted in the Piltdown endocranial cast—features which were advanced in support of the "dawn man" concept of the synthetic Sussex monster! Available evidence indicates that the cranial capacity of both the Rhodesian and Saldanha skulls is about 1250 cubic centimeters, which is well within the normal range for modern man.

Rhodesian Man has often been regarded as an African variety of Neanderthal Man; and both Singer (*1*) and Drennan (*3*) have obviously been thinking in this direction with respect to Saldanha Man. Singer is the more explicit; he labels both Rhodesian Man and Saldanha Man examples of an "African Neanderthalian," which, however, differs markedly in many respects from Neanderthal Man of Europe. Yet he emphasizes that the brow-ridges represent the only indication of a Neanderthal "streak" in the Saldanha specimen. Such phenotypic resemblances, however, do not necessarily indicate close genetic relationship. They may merely be expressions of basic morphological characters common to the whole of the primitive human stock, which have appeared independently in different radiations and at different times. They may, for all that we know, even stem from different complexes of genes. Thus, there are different sorts of brow-ridges in man, whether fossil or extant. Some are basically the result of osseous hypertrophy, whereas others are the result, at least in large degree, of greatly expanded frontal sinuses. Moreover, identification of "Neanderthal" fossils in all parts of the world represents a hang-over of the now generally discarded concept of a "Neanderthal stage" in the evolution of the modern type of man.

On the basis of the differences between the two skulls, both observed and reconstructed, Drennan originally was inclined to regard the Saldanha specimen as a separate regional variety of, and as possibly a more primitive forerunner of, the Rhodesian race (*2*). Later, relying heavily on a comparison of their endocranial casts and presumed differences in lower jaw structure, he concluded that the Saldanha skull is of a "lower morphological grade" than the Rhodesian, and that the relationship of these two fossils is probably not lineal but collateral (*3*). Consequently, he created a new species for the Saldanha specimen, terming it *Homo saldanensis*.

This creation of a new species for the reception of the Saldanha skull is to be deplored. There has already been too much blithe creation of new species or even genera of fossil men—a practice which has cluttered and confounded the terminology of paleoanthropology. Furthermore, Drennan's assessment of the status of Saldanha Man is open to at least reasonable doubt, for it tends to ignore the natural phenomenon of individual variability within populations and is, therefore, a reversion to the concept of "type," an outmoded taxonomic concept that continues to plague paleoanthropology. Singer (*1*), however, regards his observed differences between the Saldanha and Rhodesian skullcaps as falling "within the limits of individual variation." Drennan (*3*) himself notes that the Saldanha skull is "another example of the diversity of character which appears to pervade fossil man." It can be reasonably argued that this diversity is apparent within a species, probably even within a lower taxonomic level. Hence, on the basis of the recent detailed descriptions of his skullcap by Singer and Drennan, there appears to be no good reason for regarding Saldanha Man as specifically different from Rhodesian Man; this despite possible differences in facial structure. Indeed, in line with current tendencies in taxonomic procedure, these two African fossil men can be regarded as belonging to one and the same subspecies of *Homo sapiens*, which may be designated *Homo sapiens*

The author is professor of physical anthropology at the Johns Hopkins University, Baltimore, Maryland.

rhodesiensis. Or, by those who regard these two fossils as specifically different from modern man, they may be designated as merely varieties of *Homo rhodesiensis*, the name originally applied to Rhodesian Man. Whatever the preference, either of these classifications would invalidate the terminology suggested by Drennan.

The taxonomic views of Singer (*1*) with respect to Saldanha Man are not entirely clear. It is evident, however, that he would not separate him from Rhodesian Man, for he states that the Saldanha discovery "confirms that the Rhodesian skull is no isolated, abnormal or pathological type of primitive man." This also appears to be the opinion of Sir Wilfrid LeGros Clark (5), who states that the Saldanha skullcap is "almost a replica of that of Rhodesian Man" and that its discovery is "important because it confirms the evidence of Rhodesian Man that there was a rather aberrant type of *Homo* in Africa at the end of the Pleistocene, and because it suggests that this type may have been in existence there over a considerable period of time."

An extensive stone industry, characterized by hand axes and other implements of an Acheulian type, and a large fossil vertebrate fauna were associated with the Saldanha skull. From the archeologic, paleontologic, and geologic evidence, as well as from results secured by the fluorine-dating method, it appears likely that Saldanha Man can be assigned to the early part of the Upper Pleistocene (*1*), at a time probably prior to the last glaciation in Europe (*5*). The skeletal remains of Rhodesian Man, on the other hand, were associated with a different culture. These artifacts, which include quartz flakes, round bolas-stones, and bone points and gouges, are in the Levalloisian tradition (*6*). Chemical studies (analyses of lead and zinc content) indicate that the human and other animal remains found at Broken Hill are approximately contemporaneous (*7*). The total evidence, while short of being conclusive, assigns Rhodesian Man to the Upper Pleistocene (*6, 8*) at a time that is probably equivalent to the Upper Paleolithic of Europe (*7*). If so, he would appear to be more recent than Saldanha Man.

As is noted in the preceding paragraph, the site of the Saldanha discovery is characterized by an extensive stone culture. In addition, two so-called "crude bone implements" were recovered. Interpreted as "fossilised bone chisels made by prehistoric man from the metacarpal bones of horse" (*9*), they have been regarded as particularly significant in being the first such implements found in association with the older South African cultures. These bone "chisels" have recently been studied by Singer (*10*). Actually they are equid metatarsals, of which the distal extremities have been fragmented. However, they are not identical in form, as was originally supposed, and, what is the most significant, they clearly exhibit furrows such as would be made by the teeth of carnivores. Bones of other fossil mammals from the same site also were found to exhibit manifestations of tooth marks or fragmentation which produced bizarre shapes resembling chisels, cleavers, and the like. Recent bones from a cave in Fish Hoek, which could not have been inhabited or frequented in recent times by man, show similar evidence of mutilation by the teeth of carnivores. Since various fossil Carnivora occur at the Saldanha site, Singer concludes that "there can be no doubt" that the so-called "bone chisels" or implements thought to have been made by man are actually only bone fragments originally chewed by carnivores and then subjected to weathering.

This study of Singer's (*10*) has implications that extend beyond any interpretation of the cultural capacities of Saldanha Man. It indicates the need for a careful assessment of the reality of other early, supposed bone tools, such as those of the so-called "osteodontokeratic culture" recently attributed by Dart (*11*) to the fossil Australopithecinae of Makapansgat—those early Pleistocene "man-apes" of South Africa.

References

1. R. Singer, *Am. J. Phys. Anthropol.* n.s. **12**, 345 (1954).
2. M. R. Drennan, *Am. Anthropologist* **56**, 87 (1954).
3. ———, *Am. J. Phys. Anthropol.* n.s. **13**, 625 (1955).
4. G. E. Hutchinson, *Am. Scientist* **45**, 88 (1957).
5. W. E. LeGros Clark, *History of the Primates* (British Museum, Natural History, London, ed. 5, 1956).
6. K. P. Oakley, *Man the Tool-maker* (British Museum, Natural History, London, ed. 2, 1950).
7. ———, *Yearbook of Phys. Anthropol.* (*1949*) **5**, 53 (1951).
8. J. D. Clark, *J. Roy. Anthropol. Inst.* **77**, 13 (1950); S. Cole, *The Prehistory of East Africa* (Penguin Books, London and Beccles, 1954).
9. M. R. Drennan, *Illustrated London News* **223**, 480 (1953).
10. R. Singer, *Am. Anthropologist* **58**, 1127 (1956).
11. R. A. Dart, *Ann. Rept. Smithsonian Inst. for 1955* (Washington, D.C., 1956), p. 317.

Mathematics in the Soviet Union

A. J. Lohwater

I had been living in Helsinki, Finland, for almost a year as a Guggenheim and Fulbright scholar when, early in June 1956, I was invited to give a mathematical address at the third Congress of Soviet Mathematicians to be held in Moscow beginning 25 June 1956.

Since the congress was the first such convention in more than 20 years, the organization committee decided, at almost the last minute, to invite about 40 foreign mathematicians, whose research was of current interest to Soviet mathematicians. All expenses for the foreign mathematicians, except travel, were to be borne by the Soviet Academy of Sciences; my travel expenses were paid by the Guggenheim Memorial Foundation. Norman Steenrod of Princeton University was the only other delegate from the United States; it is perhaps amusing to note that, until the congress in Moscow, we had not met each other.

General Characteristics of the Congress

The meeting was similar in character to a national meeting or convention of any one of our scientific societies; there were lectures to the general membership of the congress, special sections for research papers in the various specialties of mathematics, a business meeting of their mathematical society, scheduled entertainment of various sorts, and, of course, a banquet at the close of the con-

Dr. Lohwater is professor of mathematics at the University of Michigan, Ann Arbor. He was one of the two official representatives of the American Mathematical Society at the congress described in this article.

gress. The foreign guests were given comfortable quarters in the Leningradskaya Hotel, a modern deluxe hotel catering mostly to guests of the state, while most of the Soviet members of the congress were put up in vacant student dormitories at the new Moscow State University, where the congress took place.

Following a reception for the foreign guests at the Academy of Sciences building, the congress was opened with ceremonies at the new buildings of the Moscow State University. After a welcoming address by Academician I. M. Vinogradov, each foreign country was introduced, through one of its delegates, and the warmth of the ovation given to the American delegation, both before and after it extended greetings from colleagues in the United States, made it appear, at that time, that we were attending the birth of a new era in cultural and scientific relations between the two countries.

Opening session of the congress. The American delegate extends greetings from his colleagues in the United States. For most Soviet mathematicians present, this was their first opportunity to see and hear an American mathematician. [Photo by Soviet newsman]

When the formal part of the opening ceremonies was over and the relations became more personal, the warmth of their welcome made itself felt. The Western mathematical literature is quite easily available in the Soviet Union, particularly in the larger mathematical centers, so that the names of many American research workers are well known there, just as we are acquainted with the publications of most of the more important Soviet mathematicians. We were continually asked about our American colleagues: what sort of people were they, for example, and with what sort of problems were they presently concerned. The Soviet mathematicians seemed to be particularly delighted to learn something personal about American mathematicians, something which made the Americans more human and more than merely names on research articles. Some of the queries indicated just how long certain Russians had been out of touch with the West; for example, I was asked what R. C. Paley was working on these days. (Paley, whose best known work is his book on Fourier integrals with N. Wiener, died in 1933). Many of the older Soviet mathematicians had been acquainted with various American mathematicians in the 1930's and naturally inquired about them; I was given many messages and letters to send to them as well as letters to relatives from whom they had heard nothing in years.

For me, one of the most important aspects of the congress was the opportunity to "talk shop" with my Russian colleagues whose papers I had read. This sort of intercourse forms the heart of all national and regional mathematical meetings in America, and I must remark that the facilities there to encourage this exchange of ideas were among the best that I have ever encountered. In the halls of the university outside the rooms in which research papers were being presented were tables and chairs, and a huge commons room was set aside for the use of members of the congress; a wide variety of free refreshments was available at all hours.

The conduct of the section meetings for contributed papers gave some insight into Soviet mathematics and indicated that the Russian mathematician is not very different from his American counterpart. Following each research paper, the meeting was thrown open to discussion, and the spirit of the mathematical discussions was very much the same as it is at American meetings. If a listener believed that a result was trivial or already in the literature—Soviet or Western—there were no inhibitions about bringing this belief to the attention of the speaker and audience, even if the speaker was an exalted member of the Soviet academy. It seemed to me that the free spirit of inquiry would have ridiculed out of existence any attempt to base some mathematical conclusion on political ideology; later conversations with Soviet colleagues brought out the amused remarks that such attempts had been made at various times but that the reactions of their colleagues had served only to accelerate the passage of such results together with the sponsors into mathematical oblivion. To be sure, since the Russian literature is that which is most available to the mathematicians of the Soviet Union, and since many new results are discovered simultaneously here and there, it is natural that, in many instances, the Western results are for a period unknown there and, consequently, are not referred to.

There are mathematicians in the Soviet Union, too, who attempt to further their own positions by a studied ignorance of the Western literature and by an obsequious nationalism regarding scientific priority; such scientists have their counterparts in all countries. I did not encounter this sort of nationalistic obsession among those mathematicians whom we judge to be of the first rank, and I think that the following episode illustrates the point which I have made. A mathematician who, in my judgment, has not made contributions of any significance, was giving a survey of results in the theory of univalent analytic functions. In the course of this survey he was attributing most of the progress to I. E. Bazilievich and the late G. M. Goluzin, who, to be sure, have achieved stature of the first rank for themselves for their contributions to this field. Both Cartwright of Cambridge University, for whom I was providing a running account of the talk, and I were extremely uncomfortable by the almost pointed avoidance of the spectacularly powerful results which had been achieved recently by W. K. Hayman, who is one of England's greatest mathematicians, and, at the end of the talk, we were about to point out this omission, when Bazilievich himself rose and delivered a 20-minute outline of Hayman's results and methods concerning the coefficient problem for univalent functions.

Quality of Technical Education

Despite the fact that I personally cannot understand the appointment of one or two mathematicians to the Soviet Academy of Sciences, I believe that Soviet mathematics has been particularly impenetrable to the political and authoritarian dogma which has seriously compromised certain fields such as biology. Indeed, great concern was expressed to me by dozens of mathematicians about the training of Soviet engineering stu-

dents. Acting on the assumption that the performance of a class of engineering students in their first-year mathematics course is a fairly reliable gage of the technical promise of the new group, I attempted to learn whether the reported increase in the number of Soviet engineering students had been accompanied by a corresponding decrease in the quality of their technical education. In America, of course, we have suffered certain growing pains since World War II, both in the public schools and in the colleges, and have witnessed a frightening drop in standards, both in the material taught in the schools and colleges and in the admission requirements in all but a handful of our colleges. Many university presidents and administrators have used the reported increase in the number of Soviet engineering graduates as a pretext to assert that, for patriotic and other reasons, we must enlarge existing university facilities to accommodate excessive numbers of students. I have seen it happen all too often that, in order to fill the new dormitories, the universities must resort to lowering admission requirements and soliciting students in the high schools.

I therefore took every possible opportunity to discuss with Soviet mathematicians the teaching of mathematics in the Soviet Union. I was particularly interested in the views of those who could compare the situation of today with that of 10, or even 20, years ago. Each of the professors to whom I spoke—and I discussed the problem with professors from about a dozen large technical institutes as well as from the large centers in Moscow and Leningrad—was alarmed by the calibre of student which the reduced admission standards had forced him to confront, especially in the last 10 years which have constituted the period of most intensive growth. I had a very interesting conversation with the head of the mathematics faculty in one of the largest engineering schools in Russia; he showed me the final examination given this past year to first-year students. In deploring the decline of standards, he asserted that one of the objects of the Ministry of Higher Education was the propaganda value of the mass production of technicians. It was not denied, however, that all of these technicians will be useful in the industrialization of the Soviet Union.

Although the demand for technically trained personnel has bloated the technical schools with its resultant effects on Soviet standards, it must be pointed out that the Ministry of Higher Education has been keenly aware of the effect on students of superior intellectual capacity of being presented an intellectual training geared down to the level of students who are either not capable or not interested in it, a problem which we are only now coming to recognize.

Banquet at end of the congress. Menshov (U.S.S.R.) (center) tells anecdote to Lohwater as G. Kurepa (Yugoslavia) tries to listen. On far left is the delegate from the People's Republic of China. [Photo by Soviet newsman]

Of all the differences in American and Soviet education, that which impressed me most, I found, was the appreciation there of the really gifted student, who is sifted out and not committed to the stultifying process of the huge educational production line. Such a student comes early under the influence of the greatest scholars in his field, and he forms with his teachers a relationship similar to that in the old German universities. The Soviet Union is producing several exceptionally powerful young men; for example, in my field (complex variables), a young man in his twenties, A. A. Goldberg, one of several excellent students of L. I. Volkoviskii of Molotov State University, has given a remarkable solution of a famous problem of Nevanlinna concerning the defective values of a meromorphic function. I felt that Steenrod had the same impressions concerning the training of research workers in the field of topology; in particular, he was deeply impressed by the work of the young topologist, M. M. Postnikov.

Steps toward an Exchange Program

On the evening of 27 June many of the foreign delegates were guests at a reception held by V. P. Elyutin, the Soviet Minister of Higher Education. There were about 100 people present, including many members of the Soviet academy from fields other than mathematics. During the last hour of the reception I was asked to join a group of people consisting of Elyutin and several members of the Soviet academy for the purpose of formal toasts before some Soviet reporters and photographers.

As an individual, Elyutin was quite friendly; however, as a politician, he seemed more immune to the cordial spirit displayed by everyone else we encountered at the congress, and he seemed to feel that he had an obligation to his press to confront me with the shortcomings of American foreign policy. The nature of his first question—whether I had seen the highly publicized Iron Curtain on my train ride down from Helsinki—prompted me to abandon the use of Russian during the interview and to make formal use of an interpreter so that no misunderstandings might arise. Following this line of questioning, he asked me how long it had taken me to obtain a visa at the Soviet embassy in Helsinki and whether it had been necessary for me to submit to the humiliation of being fingerprinted. We discussed the concept of fingerprinting in great detail, from its widespread use in America as a means of identification of criminals and government employees to the general revulsion throughout Europe against its use as a requirement for an American visa. When this topic had been exhausted, Elyutin expressed the hope that our visit, and that of the American physicists, marked the beginning of a fruitful exchange of scientists. He remarked that a limited student-exchange program was being contemplated, to commence in the fall of 1956, but that, unless the State Department rescinded its fingerprinting requirement, he would announce the cancellation of the exchange program before the first of September. (On my return to the United States in August, I read of the collapse of the contemplated exchange of the students.)

On 29 June I was guest of honor at a luncheon held by Academician M. A. Lavrentiev at the Praga Restaurant in Moscow; the purpose of the luncheon was to discuss details of the possible fu-

ture exchange of mathematicians between the United States and the Soviet Union. In addition to Lavrentiev there were present Academician A. I. Markushievich and L. I. Volkoviskii, P. P. Kufarev, and P. P. Belinskii.

A friendly and encouraging atmosphere prevailed, partly because all of us have conducted research in the same fields and were well acquainted with the work of one another, and partly because of a genuine desire on both sides to initiate a period of increased intercourse between the mathematicians of both countries. It was agreed at the outset by all of us that an unfortunate set of relations prevails between the U.S.S.R. and America and that the hopes of our discussion would not be furthered if we were to spend our time attempting to fix the blame for the political situation. Instead, we agreed to define those problems whose solutions would contribute most to our common goal, namely, the earliest possible successful exchange of our mathematicians.

I was careful to make it clear to them that I had with me no authority to speak officially on behalf of any American organization, a fact which was known to them at the time of my arrival in Moscow. We then reviewed our conceptions of the problems to be encountered in issuing invitations. On the Soviet side, the problems are simpler, because the decision of the Soviet Academy of Sciences to invite an American scientist implies the approval of the Soviet Government, so that a formal invitation from the academy would be sufficient for an American to obtain a Soviet visa. The problems are considerably more complicated on our side. We must first persuade some institution—a university, scientific society, or philanthropic society—to provide the funds in order to substantiate such an invitation. With this part of the problem, we do not expect insurmountable difficulties. The difficult part of the problem appears when the institution sponsoring the invitation seeks to persuade the State Department to issue a visa so that the foreign scholar may enter the United States. It was almost impossible, I pointed out, for me to describe adequately the difficulties to be encountered with this second part of the problem. I mentioned that one of our principal difficulties with this part of the problem was trying to discern some sort of consistent policy. They asserted that they were as well aware of this facet of the problem as I and that the fingerprinting requirement was only one of the barriers to be overcome.

As a possible means of overcoming a part of this problem, it was suggested that each side proceed, although it was not to be expected that both be successful simultaneously in the effort to extend

At the reception given by V. P. Elyutin (Soviet Minister of Higher Education). Left to right: Elyutin, Lohwater (U.S.A.), F. Severi (Italy), A. Denjoy (France), and M. A. Lavrentiev, I. M. Vinogradov, and I. G. Petrovskii. Petrovskii is rector of the Moscow State University. [Photo by Soviet newsman]

invitations. If, as seemed probable, the Soviet academy were the first to obtain official approval to extend an invitation, it should proceed to do so, for the effect would be to stimulate the efforts being made on our side.

We then discussed what could be expected in the matter of expenses for the visiting scholars. I was told that the Soviet academy would either provide or pay for transportation to America and return for whomever we invite but that all other expenses inside America should be provided by us. Conversely, an American scholar who is invited to the Soviet Union will be expected to get there at his own expense, but that, once there, he will be provided with everything else. I remark, parenthetically, that if the level of hospitality shown to Steenrod and me during our visit is an indication of what our next man is to expect, let us hope that he has a strong constitution!

The nature of the activities of the scholars under the exchange was then brought up. It was asserted that, as things stood then in the academy, it would not be convenient for an academician to visit for more than a month or two, a remark which had been made to me at Elyutin's reception by other officials of the academy. Thus, in its first stages, the exchange is anticipated to be no more than a series of lectures at the research level, rather than in the nature of visiting professorships or research study grants which could come later, if and when the scope of the exchange program is enlarged. They mentioned the names of several American mathematicians in whose work they were interested; I presume that these will be among the first to be invited.

It appears to me from the discussion at this formal meeting, as well as from other conversations, that we are expected to invite, if only in our first invitation, someone of academy stature, and I feel convinced of the need for observing this protocol. In mathematics, to be sure, a large part of the research is produced by relatively young scientists, and, from our observations there, the situation in the Soviet Union is no exception to this rule. Now it is natural for us to want to hear from those mathematicians who are at the height of their creative periods; on the other hand, their assertions to the contrary, the young do not have a mo-

Luncheon held at Praga Restaurant to discuss details of exchange of mathematicians. Left to right: A. I. Markushievich, L. I. Volkoviskii, P. P. Kufarev, Lohwater, P. P. Belinskii, and M. A. Lavrentiev.

nopoly on creativity, and there are many members of the Soviet academy who are extremely productive, so that it is possible to observe the formalities which I judge are expected of us and, at the same time, to invite someone who can offer us considerable scientific stimulation. A possibility which might satisfy both points of view is that we invite one or more academicians together with an equal number of their gifted young mathematicians.

Since the congress last summer, the upheavals in eastern Europe have changed drastically not only many of our conceptions of Soviet-American relations but also the Soviet conceptions of these relations. It does not speak well of either of the two governments that almost the first expression of displeasure at the turn of events in the satellite countries was the summary curtailment of all cultural relations between the two countries. For if it is our long-range intention not to live in perpetual hostility to the Soviet Union—and the logical consequences of the hypothesis of perpetual hostility are obvious—then it appears to me that each side has struck at the best means of implementing its long-range intention. It was my impression that the longing of Soviet scientists and other scholars for more contact with their Western colleagues is the most important fissure which has appeared in the Iron Curtain, in the sense that the proper exploitation of this fissure can lead to pressures for change inside the Soviet Union by a group of people of considerable prestige and influence: the sort of pressures which we have asserted would bring about those changes for which we have been hoping. In my view there exists an urgent necessity to replace and to enlarge the basis for the scientific and scholarly contacts at all levels, but at the very least, there exists the urgent necessity of examining and discussing our objectives in the general field of the cultural and scientific relations between the United States and the Soviet Union.

L. M. Terman, Pioneer in Mental Measurement

When Lewis M. Terman died, near the end of his 80th year, he was working on the manuscript of volume 5 of *Genetic Studies of Genius* and was simultaneously planning the next 3 years' research on his group of 1500 "gifted children." No other facts could mark the man so well. From 1903, when he arrived at Clark University to begin graduate work, until his death, his career was a continuous sequence of research and writing, broken now and then by illness and accident but never interrupted in its main course.

At the turn of the century, the idea of measuring human abilities was little more than a dream. To be sure, E. H. Weber had measured sensory thresholds long before, and the "new psychology" of the 1880's and 1890's had isolated such simple behaviors as discrimination and reaction time. But a man's performances in these molecular processes, it was quickly apparent, were quite unrelated to his performances as a thinking, reasoning, judging, creating human being.

A new approach was in the making, however. In Paris, Binet had discovered how to distinguish bright and dull pupils with a test composed of difficult "school-type" questions. At Teachers College, Columbia University, Edward L. Thorndike had developed tests for measuring school achievement. These efforts caught Terman's imagination at the very beginning of his graduate work. He had had sufficient experience as a school teacher himself to know of the great differences among children in their capacities for learning. He knew, too, from his own early experiences in an intellectually arid farm county in Indiana, that high talent is likely to be wasted for want of recognition and encouragement. He thought that such wastage was shameful, a tragic loss to society of its most valuable resource. He conceived of social progress as dependent on how rapidly, and with what economy, intellectual giants—"geniuses" as he later called them—could reach their maximum development and produce their great ideas. He devoted his career to developing methods of measuring intellectual ability and to discovering the qualities of those who are most gifted. In a century that has concerned itself strongly with the remedying of evils—illness, poverty, inequity—and in a science that seems, perforce, to have had to orient itself too often toward the care and understanding of the weak and inept, Terman turned resolutely toward the positive side of man's existence. As a student of the intellect, his interest in feeblemindedness was perfunctory, his zeal for the study of genius, burning.

The half-century since Terman finished his doctoral training is almost coincident with the history of mental testing. So is Lewis Terman. From the first, there was something provocative and exciting to him in the very idea of measuring complex psychological qualities. His doctoral dissertation was a comparison of seven bright and seven dull schoolboys. He gave each child a battery of more than 40 hours of individual tests, probably the most overwhelming test-assault inflicted on any child up to that time. Nothing much came of the study, but it did give Terman a chance to try his hand at making up tests. He loved it, and he went right on loving it to the end of his life. He built test after test for 40 years, all of them good (technically) and nearly all of them useful.

His first major venture was the revision of Binet's intelligence test. He began this task when he went to Stanford University as an assistant professor of education, in 1910. The Stanford-Binet test, as he called it, became at once the standard intelligence test for use in schools and clinics throughout the United States. His selection of a score for the test—the IQ—proved immediately popular. As a simple measure of the influence of Terman on modern society, try to imagine eliminating the IQ from our language!

Although Terman received his doctor's degree in both psychology and pedagogy, he was perhaps more closely associated with the latter than with the former in his early years at Stanford University. He was in the School of Education. The department of psychology was tiny, experimental in the Wundtian sense, and, with respect to research, essentially moribund. When he published *The Measurement of Intelligence,* in

1916, Terman was not even a member of the American Psychological Association.

Then came World War I. With a great mass of men drawn into the military services, the need for selection devices was serious and immediate. Under Robert M. Yerkes' direction, a group of psychologists went to Washington to prepare appropriate tests. Among them was Terman, and there he rediscovered his kinship with psychologists. A list of the group that constructed the Army Alpha and Beta tests reads like a Who's Who of American psychology in the first quarter of the century. Many of them were originally of the hard-bitten, experimentalist school, and their acceptance of Terman's contribution to the measurement problems imposed by the national emergency reinforced his conviction that mental tests are not only of practical significance but are an integral part of scientific psychology. He never lost his belief in the importance of the educational applications of testing, but after the end of World War I, Terman was primarily a psychologist. He joined the American Psychological Association, was a member of its council in 1919, and was elected president in 1923. He was elected to the National Academy of Sciences as a psychologist.

In a sense, all this was preparation, both for Terman and for the society of which he was very intimately a part. The Stanford-Binet was a thoroughly sound and useful individual test. The Army Alpha was a successful group test. Together they had paved the way for the expansion of tests into whatever realm of usage might be reasonably suggested. The need for tests was widely recognized; Terman and his colleagues had learned how to make them. For some few years after he returned to Stanford University from Washington, Terman practiced his skill, in collaboration with T. L. Kelley, G. M. Ruch, and others. The Stanford Achievement Tests and the Terman Group Test were perhaps the most widely known products of this period.

Not everyone was enthusiastic about mental testing. Some philosophers, some humanists, some "wise" laymen of indecipherable antecedents but of wide journalistic following were distressed no end by the notion that the mind could be measured. Not more than two decades before, the very idea of mind as a measurable process had scarcely been suggested. The philosophy of nonscientists, even in 1920, was essentially dualistic and, to many, the mind was still ineffable.

As the most visible proponent of mental testing, Terman was the focal point of attack from these sources. He bore up well, though with occasional acerbity. His answers to the more "sophisticated" attacks were not brilliant in the philosophic sense. He was no philosopher. He answered in the language a scientist knows best—the empirical. He rested his case on the simple fact that when a sample of behavior is measured under standard conditions with a standardized measuring instrument, future behaviors of a specifiably similar kind can be predicted with a knowable degree of error. There was no metaphysical principle discernibly involved in the argument. Not surprisingly, the argument ultimately carried conviction, even to those who had begun by opposing it. In the long history of man's attempt to make the universe seem lawful and orderly, mental testing, as Terman and others practiced it in the first quarter of this century, has probably played the largest part in contributing an empirically legitimate sense of order and lawfulness to those events in the universe that are composed of the behavior of man himself.

Test construction was not Terman's main interest for long, however. In 1921 the Commonwealth Fund provided him with a grant large enough to enable him to begin the study of a large group of gifted children. By diligent search through the California schools, he was able to locate 1500 youngsters, of average age 11, who had IQ's above 140. Terman's object was to discover what the intellectual and other characteristics of such a group were. He was distrustful of the common myth that the brilliant youngster was peculiar, unhealthy, and doomed to early deterioration. His observations during the course of test construction had led him to the hypothesis that children with high IQ's become adults with equally high intelligence.

The results of Terman's study are so widely known that they need no summary. In brief, he was right. But, not content with following the group just long enough to discover that "good things go together," he decided to make sure once and for all that the gifted child of today is the leader of tomorrow. To this end, he followed the group continuously until his death, by which time their average age was 46. His warmth and kindness, his perpetual eagerness to help and counsel, brought him the enduring friendship of his "children." He could easily have answered the questions he sought to answer by retaining contact —over 35 years—with half of the group. Actually, as of 1957, 93 percent of the living members are still active participants.

The social importance of this study, chronicled as it is in the successive volumes of *Genetic Studies of Genius* and in dozens of articles in technical journals, cannot be overestimated. In the field of education, it has given great impetus to the discovery and maximizing of talent. It has made abundantly clear where society's strongest resources lie, and, more generally, it represents the final squashing of the age-old theory of compensation among man's good qualities. There are no negative correlations between intelligence and strength, size, physical vigor, and emotional stability. On the contrary, where correlation occurs at all, it tends to be slightly positive. Never again can literate men look on a bright child as being, somehow, a kind of bad seed.

ROBERT R. SEARS
Department of Psychology, Stanford University, California

News of Science

Another Nobelist Urges Nuclear Test Ban

Another Nobel laureate, Linus Pauling, head of the division of chemistry and chemical engineering at California Institute of Technology, has publicly called for the cessation of hydrogen bomb tests. In Chicago recently he warned that the proposed British test in the Pacific would cause 1000 cases of leukemia and suggested that cancellation of the test be the first step in international disarmament.

Pauling also stated that radioactive materials released by current nuclear explosions are causing a 1-percent increase in the total number of mentally retarded or deformed children born in the world. He said this would be an increase of 200,000 in one generation.

When told of Pauling's statements, Samuel K. Allison of the University of Chicago's Nuclear Physics Institute, said:

"Dr. Pauling is well informed in his field, and knows what he is talking about. His statement is worthy of publication. . . . I am in favor of discontinuing tests of bombs above one megaton (equivalent to a million tons of TNT)." Allison, one of the leaders in producing the first A-bomb, also agreed with Pauling about the British test.

National Academy of Sciences Award Winners and New Members

At the 94th annual meeting of the National Academy of Sciences, which took place 22–24 Apr. in Washington, D.C., the following men were honored.

James R. Killian, Jr., president of the Massachusetts Institute of Technology, received the Public Welfare Medal, generally recognized as the most distinguished of the academy's medals. It is unique in that it is awarded for the application of science in the public interest, whether by a scientist or not, rather than for specific scientific achievements.

Killian was inaugurated as the 10th president of the Massachusetts Institute of Technology in April 1949 at the age of 45. His administration has been marked by an increased emphasis on general education and the humanities in the education of scientists and engineers, by the development of M.I.T. as a residential college, and by the institute's steady evolution into a "university polarized around science."

Sven P. Ekman of Uppsala, Sweden, received, in absentia, the 1953 Daniel Giraud Elliot medal, which is given for "the most meritorious work in zoology or paleontology published each year." Every year the committee of selection reviews the literature of 3 years back in order to have the advantage of the perspective of passing time. For 1953 the committee selected Ekman's book, *Zoogeography of the Sea*. This work, issued in Great Britain, is a volume of 417 pages outlining our modern understanding of ecological distribution of marine animals. Containing much learned discussion and significant information on the relationships of the various faunas throughout the seas of the world, it embodies the summary of a lifetime of research on the part of the author.

Ekman progressed through successive appointments at the University of Uppsala until he became a professor in 1927. He also served as director of the university's Klubban Zoological Station and of its Zoological Museum until he was given emeritus status in 1941. He has worked extensively on the systematics of the Holothurians, of certain Hydroids, of Amphipods, and of other crustaceans, in addition to his general studies of zoogeography.

A. H. Sturtevant, professor of genetics at the California Institute of Technology, received the Kimber Genetics medal "for his long and distinguished career as discoverer and interpreter of fundamental genetic phenomena, as observed not only in the fruit fly but also in a number of other organisms, plant and animal; and for his brilliant studies on the evolution of genetic systems." One of Sturtevant's earliest and most important contributions to genetics was his demonstration that the genes are located in single linear order on the chromosomes, and that it is possible to establish the order in which the genes are arranged.

At its business session, the academy elected a vice president, two members of the council of the academy, 30 members, and four foreign associates. Farrington Daniels, professor of chemistry, University of Wisconsin, was elected to serve as vice president for a 4-year term beginning 1 July 1957, succeeding George W. Corner who has served since 1 July 1953. Daniels has been a member of the council for the past 3 years. Harry L. Shapiro, chairman of the department of anthropology, American Museum of Natural History, New York, and Frederick Seitz, professor of physics, University of Illinois, were elected to membership on the council of the academy to succeed Farrington Daniels and Merle A. Tuve.

Present officers of the academy, all of whom are members of the council, are as follows: president, Detlev W. Bronk; vice president, George W. Corner; home secretary, Hugh L. Dryden; foreign secretary, John G. Kirkwood; treasurer, William J. Robbins. Additional members of the council at the present time are E. A. Doisy, Farrington Daniels, Theophilus S. Painter, I. I. Rabi, F. E. Terman, and Merle A. Tuve.

Newly elected members of the academy are Charles A. Anderson, chief, Mineral Deposits Branch, U.S. Geological Survey, Washington, D.C.; Edwin B. Astwood, New England Center Hospital, Boston, Mass.; Joseph C. Aub, Massachusetts General Hospital, Boston, Mass.; Hendrik W. Bode, director of research in physical sciences, Bell Telephone Laboratories, Murray Hill, N.J.; Herbert C. Brown, professor of chemistry, Purdue University; Edwin H. Colbert, curator of fossil reptiles and amphibians, American Museum of Natural History, New York; Joseph L. Doob, professor of mathematics, University of Illinois; Paul M. Doty, professor of chemistry, Harvard University; Charles S. Draper, professor of aeronautical engineering, Massachusetts Institute of Technology; Walter M. Elsasser, professor of physics, University of Utah; Katherine Esau, professor of botany, college of Agriculture, University of California, Davis; Jesse L. Greenstein, staff member, Mount Wilson and Palomar Observatories, Pasadena, Calif.; Alexander Hollaender, director, Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.; Donald F. Hornig, professor of chemistry, Brown University; Joseph Kaplan, professor of physics, University of California, Los Angeles; Charles Kittel, professor of physics, University of California, Berkeley; Heinrich Klüver, professor, division of biological sciences, University of Chicago; Arthur Kornberg, professor of microbiology, Washington University Medical School, St. Louis; Joshua Lederberg, professor of genetics, University of Wisconsin; Howard J. Lucas, emeritus professor of chemistry, California Institute of Technology; Alden H. Miller, professor of zoology, University of California, Berkeley; Hallam L. Movius, Jr.,

curator of Palaeolithic archaeology, Peabody Museum, Harvard University; Severo Ochoa, professor of biochemistry, New York University Medical College; Roger R. D. Revelle, director, Scripps Institution of Oceanography, La Jolla, Calif.; Leonard I. Schiff, professor of physics, Stanford University; John C. Sheehan, professor of organic chemistry, Massachusetts Institute of Technology; Joseph E. Smadel, director, Communicable Diseases Division, Army Medical Service Graduate School, Walter Reed Army Medical Center, Washington, D.C.; Cyril S. Smith, professor of metallurgy, University of Chicago; Robert R. Wilson, professor of physics, Cornell University; Jerrold R. Zacharias, professor of physics, Massachusetts Institute of Technology.

Newly elected foreign associates are Heinz Hopf, professor of higher mathematics, Swiss Federal Institute of Technology, Zurich, Switzerland; Axel H. Theorell, head of biochemistry department, Nobel Medical Institute, Stockholm, Sweden; Edgar W. R. Steacie, president, National Research Council, Ottawa, Canada; N. F. Mott, professor of experimental physics, Cavendish Laboratory, Cambridge, England.

Army Package Power Reactor

The Army Package Power Reactor (APPR) prototype stationary nuclear power plant developed by the Atomic Energy Commission for the Department of Defense, generated electricity for the first time during test operations last month at the U.S. Army Engineer Center, Fort Belvoir, Va. The reactor is termed a "package" power plant because it is designed so that its components may be transported by air for use at remote military installations, such as arctic bases.

AEC Field Inspection Groups

The U.S. Atomic Energy Commission has established inspection groups in nine of its operations offices located throughout the United States. Each office has been assigned a specific geographic area and is responsible for the inspection in that area of access permit holders and users of uranium, thorium, and radioisotopes under commission license. Inspection of licensed production and utilization facilities, such as reactors, will continue to be made by the Division of Inspection in Washington, D.C.

Each field office will be responsible for gathering information to show whether or not commission licensees and access permit holders are in compliance with the commission's rules and regulations and with special conditions in the permit or license. (Permits authorize access to classified information and licenses authorize possession and use of radioactive materials.) Field inspection groups will work closely with state inspection agencies. It is anticipated that federal and state cooperation in inspection activities will be enlarged as the inspection program is further developed.

NSF Institute Program

The National Science Foundation has announced that it will accept proposals for support of summer institutes in 1958 and of academic-year institutes during 1958–59. The institute program is designed to help teachers of science and mathematics improve their subject matter knowledge and their teaching capabilities. The current program will support 96 summer institutes this year, and 16 academic-year (1957–58) institutes in colleges and universities throughout the nation.

Academic-year institutes offer full-time work during the regular school year that is designed especially for secondary-school teachers. The foundation supports attendance of such teachers; this support includes dependency, book, and travel allowances. In addition, proposals may request funds for tuition and fees and other operating costs.

Summer institutes also offer work in the subject matter of the sciences and mathematics especially designed for teachers. Proposals may be presented that are designed for the special needs of high-school teachers, college teachers, or science supervisors. Foundation support may be requested for stipend, dependency, and travel allowances, tuition and fees, and other operating costs.

Directions for preparing proposals and forms to be used in making application may be obtained by interested institutions of higher education from the Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C. Deadlines are *1 Aug. 1957* for submission of proposals for institutes to be held in the summer of 1958; *1 Sept. 1957* for proposals for support of academic-year institutes during 1958–59.

Stellarator at Princeton

The U.S. Atomic Energy Commission has approved plans for the design and construction of a large experimental device for research on controlled thermonuclear reactions at the Forrestal Research Center at Princeton University. The machine, named the Model C Stellarator (coined from *stellar* and *generator*), will not be a pilot plant or prototype of a thermonuclear power plant. It will be exclusively a research tool, making possible experimental work which cannot be performed as effectively with smaller models. Experiments with the stellarator are expected to begin late in 1960 or in 1961.

The stellarator consists essentially of a hollow tube containing ionized gas. Around the tube are external coils which produce a magnetic field to confine the gas. The objective of the research program is to heat the gas to temperatures of millions of degrees and at the same time to confine the heated gas within the tube for enough time to allow fusion reactions to take place.

A research team at Princeton has been engaged since 1951 in the controlled fusion research program under contract with the AEC. In addition to theoretical work, the Princeton group has conducted extensive experimentation with small stellarator models. The controlled thermonuclear project at Princeton is under the direction of Lyman Spitzer, Jr., and the work is under the general supervision of a committee headed by H. D. Smyth, formerly a member of the AEC.

Southward Flow under Gulf Stream

A massive deep current flowing to the south under the Gulf Stream has been measured recently as a result of cooperation between the royal research ship *Discovery II* of the British National Institute of Oceanography and the research vessel *Atlantis* of the Woods Hole Oceanographic Institution. The use of an instrument designed by J. C. Swallow of the National Institute of Oceanography, together with a theory suggested by Henry Stommel of the Woods Hole Oceanographic Institution, has changed fundamental concepts concerning ocean currents. Observations to be made by some 70 ships during the International Geophysical Year will be much more meaningful as a result of this work.

An operating plan was decided upon by the chief scientists of both ships, H. F. P. Herdman and L. Valentine Worthington; then an area in the Gulf Stream east of Charleston, S.C., near the Blake Plateau was studied.

Swallow's new research device consists of a fairly simple electronic system sending out "pings" similar to those in use by echo-sounding. Encased in a 9-foot-long aluminum alloy pipe, 2 inches in diameter, the apparatus is neutrally buoyant, meaning that it can be made to sink to a predetermined depth where its density is equal to that of the surrounding water. There, the float remains, being carried away at the same rate and in the same direction as the subsurface ocean current.

The subsurface float is tracked with the aid of underwater sound signals.

Minimal motion of the entire water column was found at about 4500 to 6000 feet below the surface, while the velocities increased with depth below that level, as was theoretically predicted. The southerly currents ranged from about 1/10 knot to about ⅓ knot at depths of approximately 8400 feet. In contrast, the surface velocity of the Gulf Stream in its narrow inshore edge is 4 to 5 knots. An ocean bottom photograph made by A. S. Laughton from the *Discovery II* showed a southerly current only 18 inches above the bottom, as evidenced by the direction of a ping pong ball hung by a string from a compass. It appears, therefore, that off the Blake Plateau the upper half of the entire water column moves toward the north, while the lower half moves southward.

National Medical Library

A site on the acreage of the National Institutes of Health, Bethesda, Md., has been chosen for the National Library of Medicine. The library, started in 1836, has more than 500 incunabula, many thousand rare books of later date, and a collection of theses that many medical men consider to be unsurpassed. It has 500,000 bound volumes and more than 1 million titles in medicine, public health, dentistry, and allied sciences in all languages and of all times. Also the library's collection of portraits of medical men and its photographs in the medical field are outstanding. The library, formerly the Armed Forces Medical Library, has been waiting for a new building for 40 years.

Cerebral Vascular Disease

The launching of the first, nationwide cooperative research program to combat cerebral vascular disease was announced recently by the U.S. Public Health Service. Ten medical research centers in nine states have already joined in the program, and it is expected that 35 to 40 institutions will ultimately participate. The program, which is expected to run 5 or 6 years, is under the auspices of the National Institute of Neurological Diseases and Blindness.

It has been calculated that as many as 1.8 million living Americans have suffered cerebral strokes at one time or another. Deaths due to such strokes are estimated at 175,000 annually, the nation's third ranking cause of mortality.

The new program was made possible by grants totaling $172,000 to the various participating organizations. The work will be supplemented by the 29 current projects on various aspects of cerebral vascular disease that are supported by National Institutes of Health grants amounting to about $250,000.

The new investigation will make possible a coordinated study of thousands of patients who either have suffered a stroke or who show clinical signs indicating that a stroke might be coming on. The research results are expected to shed new light on the nature and causes of strokes and to open the way to more effective treatment methods. Relatively few data are now available on the effectiveness of the various methods currently in use.

Data collected will be collated and evaluated at the University of Iowa (Iowa City), one of the cooperating institutions. Other participating institutions are the University of Minnesota, the Massachusetts General Hospital (Boston, Mass.), the University of Michigan, Duke University, the University of Pennsylvania,. Columbia University, Indiana University, the Buffalo General Hospital (Buffalo, N.Y.), and Washington University (St. Louis, Mo.).

Sherrington Centenary

This is the centenary year of the birth of Sir Charles Scott Sherrington, a founder and main architect of our knowledge of the physiology of the nervous system. The Royal Society of Medicine, London, England, wishing to pay tribute to his life and work, proposes to raise a fund toward a Sherrington lecture for the furtherance of knowledge on the nervous system, to be delivered from time to time in the society's rooms in London. It is felt that many will wish to contribute: both those who were his friends, pupils, and colleagues, and those, more numerous, who, as patients, doctors and scientists, have benefited indirectly from his work. Donations, identified as contributions to the Sherrington Memorial, should be made payable to the Secretary, The Royal Society of Medicine, 1 Wimpole Street, London, W.1.

Representatives of scientific societies supporting the appeal include: Sir Russell Brain, president, Royal College of Physicians; Sir Lindor Brown, foreign secretary, Physiological Society; John Fulton, Sterling professor of the history of medicine, Yale University; W. R. Henderson, president, Society of British Neurological Surgeons; Sir Cyril Hinshelwood, president of the Royal Society; E. G. T. Liddell, Waynflete professor of physiology, University of Oxford; D. W. C. Northfield, president, Section of Neurology, Royal Society of Medicine; Sir Clement Price Thomas, president, Royal Society of Medicine; Sir Charles Symonds, president, Association of British Neurologists; and Sir Francis Walshe, chairman, Sherrington Memorial Committee, Royal Society of Medicine.

Cancer Society Awards

The American Cancer Society has announced the award of $4,636,651 for research to 243 scientists in 108 universities and medical centers in 35 states, an all-time record for the society. The grants were made from 408 applications. The amount awarded is in addition to the $3,000,350 in grants to 46 research centers already allocated during the current fiscal year. In all the society is this year devoting $7,637,001 to cancer research.

Health Science Center at Brown

Brown University has announced the establishment of an Institute for Research in the Health Sciences to serve as a center for cooperation with hospitals and other institutions in the community and for the conduct of experimental programs in these sciences. Glidden L. Brooks, medical director of the United Cerebral Palsy Associations, has been appointed director of the institute, effective 1 July.

Initially the institute will provide means for implementing the grant received last November by the university from the U.S. Public Health Service for an investigation into the cause of cerebral palsy and mental retardation. This is part of a multimillion-dollar study in which eight colleges and universities are to collaborate. Brown University was one of the first of these educational institutions to receive a grant for carrying out the program. Awards of more than $700,000 were made to Brown and Yale universities last November for 5 years of research, with Brown receiving $97,633 for the first year's work. With the cerebral palsy program as an example, similar programs in the fields of other health sciences are expected to be undertaken in the future.

IGY Openings in Antarctic

Opportunities exist in the Antarctic program planned by the U.S. National Committee for the International Geophysical Year for scientists, engineers, and technicians at the bachelors, masters, and doctorate levels of training and experience in physics, geophysics, electronics, or closely allied areas. The U.S. Antarctic program emphasizes the following fields: aurora and airglow, cosmic rays, glaciology, gravity, ionospheric physics, meteorology, and seismology. Most of

the current openings exist in the fields of meteorology and glaciology, although the other fields still require a limited number of specialists.

Research stations have been established at Little America in Marie Byrd Land (Byrd Station), at the South Geographic Pole (Amundsen-Scott South Pole Station), on the Knox Coast (Wilkes Station), and along the Weddell Sea (Ellsworth Station).

The first group of scientists and technicians are now on-station and geophysical observations and studies are underway. The program of observations will continue until April 1959. A second group will leave the United States on about 1 Nov. 1957. Prior to departure, approximately 2 months of advanced training will be provided in problems of research, instrumentation, and operations in polar regions.

Interested candidates are invited to address inquiries to the following Antarctic Project Leaders: aurora and airglow—Mr. Norman J. Oliver, A. F. Cambridge Research Center, Laurence G. Hanscom Field, Bedford, Mass.; glaciology, gravity, and seismology—Miss Diana Fisher, Glaciological Headquarters Office, USNC–IGY, 1145 19th St., NW, Washington 6, D.C.; ionospheric physics—Mr. Harry G. Sellery, Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colo.; meteorology—Mr. Ervin A. Volbrecht, U.S. Weather Bureau, 24th and M Sts., NW, Washington 25, D.C.

Reactor for Greece

A site on the slopes of Mount Hymettus, 10 miles from the center of Athens, has been selected for the construction of Greece's first nuclear research reactor. The new facility will be known as the Democritus Nuclear Research Laboratory in honor of the Greek physicist of 470 B.C. The pool-type reactor now is being built in the United States and is due for delivery in February 1958.

News Briefs

The Atomic Energy Commission recently allowed unclassified tours for all news media at its two large Pacific Northwest installations, the Hanford works at Richland, Wash., and the National Reactor Testing Station at Idaho Falls, Idaho. This was the first time news representatives had had access to the Hanford facilities. The tour did not include plutonium production facilities there, but was limited to laboratory and test units.

* * *

A hospital for the treatment of the mentally ill is to be built by the Department of Mental Hygiene of the State of New York at a cost of $70 million on 125 acres of reclaimed marshland along the Hutchinson River Parkway in the Bronx. The new mental hospital, the first to be built by the state in 25 years, will accommodate 3000 patients.

* * *

The department of bacteriology of the University of Nebraska will offer the doctorate beginning in the fall of 1957.

* * *

The name of the Colorado Agricultural and Mechanical College, Fort Collins, Colo., was changed to Colorado State University on 1 May.

* * *

The University of Missouri School of Medicine will bestow M.D. degrees on 23 graduating students at the annual commencement exercises. Not since 1908 has the university offered a 4-year curriculum.

Proposed Legislation

Of the many bills introduced in Congress, some have a special relevance to science and education. A list of such bills introduced recently follows:

S 1298. Assist states in providing needed vocational education of less than college grade in essential occupations, including retraining made necessary by scientific and technological developments, through establishment and maintenance of area vocational school programs providing vocational training and retraining for persons residing in state or area, including related instruction for apprentices. Hill (D Ala.)

S 1229. Reduce loss of life, personal injuries, and property damage resulting from automobile accidents by establishing an automobile and highway safety division within Department of Health, Education, and Welfare to work in cooperation with public and private agencies for such purposes. Johnson (D Tex.) Senate Labor and Public Welfare.

HR 5252. Provide loans to enable needy and scholastically qualified students to continue post-high-school education. Teller (D N.Y.) House Education and Labor.

S 1326. Establish a system for classification and compensation of scientific and professional positions in Federal Government. Johnston (D S.C.) Senate Post Office and Civil Service.

H J Res 250. Establish a Joint Committee on Scientific Research. Judd (R Minn.) House Rules.

S J Res 68. Provide for construction and operation of an atomic power prototype reactor demonstration facility in state of Vermont. Aiken (R Vt.) Joint Atomic Energy.

HR 5646. Prohibit experiments upon living dogs in District of Columbia and provide a penalty for violation thereof. Burdick (R N.D.) House District of Columbia.

HR 5238. Establish a National Outdoor Recreation Resources Review Commission to study outdoor recreation resources of the public lands and other land and water areas of the U.S. Hagen (D Calif.) House Interior and Insular Affairs.

Scientists in the News

The Albert and Mary Lasker Foundation in New York has announced the eighth annual selections in the nationwide medical journalism competition covering newspapers, magazines, and radio-television broadcasts. Winners of the $2000 awards are as follows:

ROBERT S. BIRD, staff writer, *New York Herald Tribune,* for his series of six articles published in July 1956 on rising trends of venereal disease rates among teen-agers and adults in the United States.

ROLAND H. BERG, medical and science editor, *Look Magazine,* for his article, "The state of the nation's health," published in April 1956.

Public Affairs Department, Columbia Broadcasting System and Station WCBS-TV, New York, jointly, for the documentary television productions, "Out of Darkness" and "The Wassaic Story," dealing with mental illness and mental retardation, respectively, and presented over the CBS network in 1956. "Out of Darkness" was produced, written, and directed by ALBERT WASSERMAN, with IRVING GITLIN serving as executive producer. Gitlin is also director of the public affairs department. "The Wassaic Story" was written by BILL LEONARD and ARTHUR ZEGART, directed by Zegart and produced by Leonard.

JOHN F. FULTON, Sterling professor of the history of medicine at Yale University, will receive an honorary doctor of letters degree from Oxford University in England this June, as will the actor Sir Laurence Olivier. Both will be cited for distinguished contributions to English letters. Fulton is well known for his biography of Harvey Cushing and for pioneer research in neurophysiology and physiologic problems of aviation medicine.

BERNARD D. DAVIS, professor of pharmacology and chairman of that department at the New York University College of Medicine, has been appointed professor of bacteriology and immunology at Harvard University and head of

the department of bacteriology and immunology in the Harvard Medical School. He will begin his service at Harvard on 1 July.

In the field of research, Davis is responsible for the discovery that many drugs, particularly the sulfa drugs, are bound to the proteins of the blood plasma. The degree of binding to these circulating proteins determines the extent of the drug's distribution throughout the body.

He is also credited with the finding, made during research in the field of tuberculosis, that albumin promotes the growth of the tubercle bacillus by protecting the organisms from fatty acids that would normally be destructive. Recently Davis has been concerned with the study of bacterial mutants.

MUSA GHANTUS, professor of anatomy and associate dean of medicine, American University, Beirut, Lebanon, is visiting professor of anatomy at the University of Tennessee Medical Units in Memphis during the spring quarter, which ends in June. Ghantus was at the University of California at Los Angeles College of Medicine during the fall semester.

CHARLES F. BROOKS, professor of meteorology at Harvard University and head of the university's weather research station at Blue Hill, will retire this summer. Within the field of weather and climate, Brooks' interests have ranged widely: he has done a great deal of work on clouds, relationships between ocean temperature and weather, instruments and methods, snow, and climatology. He is joint author of *Climatology of North America and the West Indies, Climatic Maps of North America,* and *Eclipse Meteorology,* and author of *Why the Weather?* He also helped prepare the new 2-volume *International Cloud Atlas.*

Brooks received his A.B. in 1911 and his Ph.D. in 1914 from Harvard. He served as an instructor at Yale University, he was in the U.S. Army School of Meteorology during World War I, and later he became a professor at Clark University. Since 1931 he has been professor of meteorology and director of Harvard's Blue Hill Meteorological Observatory, in Milton, Mass.

He was the founder of the American Meteorological Society and its *Bulletin.* He served the society as its secretary for 35 years, and for 16 years was also editor. In addition, he was one of the founders of the Mount Washington Observatory, which he has directed for nearly 25 years. Brooks is a member of the American Academy of Arts and Sciences, the Association of American Geographers (past-president), and the American Geophysical Union, and a fellow of the Royal Meteorological Society of Great Britain, the American Geographical Society, and others.

DONALD SMELT, chief of wind-tunnel operations for ARO, Inc., Tullahoma, Tenn., has been named first director of the new design office in the Research and Development Branch of the Lockheed Missile Systems Division, Van Nuys, Calif. Smelt's list of aeronautical accomplishments includes: the evaluation of the German V-1 and V-2 missiles for Britain during World War II; the direction of flight-test activities for the first British jet plane; command of missile development for all British armed forces; and development of the "hot-shot" wind tunnel, which simulates not only high speed but also the temperatures of supersonic flight.

G. R. RIDINGS, formerly of the University of Mississippi Medical Center, has become the first full-time head of the department of radiology at the University of Oklahoma School of Medicine. Ridings' appointment now gives the school seven clinical departments with full-time directors.

Also at Oklahoma, HENRY B. STRENGE, head of the department of pediatrics, has resigned, effective 1 July. He has been a member of the university's faculty since 1948.

BAIRD HASTINGS, Hamilton Kuhn professor of biological chemistry at Harvard University and head of the department of biochemistry in the Harvard Medical School, has been named honorary professor on the faculty of medicine, Universidad Nacional Mayor de San Marcos de Lima, Peru. Hastings received the honor during his participation in a special convocation marking the dedication of the new Institute of Biochemistry and Nutrition at the South American university.

EDMUND N. FULKER has been appointed director of the Reading Improvement Laboratory, U.S. Department of Agriculture. He was formerly director of the Headquarters USAF Reading Improvement Laboratory, the Pentagon, where he has been succeeded by JAMES E. GILBERT.

HAROLD TORGERSON, associate dean of the College of Engineering at New York University, has been appointed dean of the School of Engineering at the University of Connecticut. He will take over his new duties this summer. He succeeds the late Francis L. Castleman, Jr.

J. STUART JOHNSON, professor and head of the School of Electrical Engineering at Purdue University, has been appointed dean of Wayne State University's College of Engineering. He succeeds acting dean REX SCHOONOVER, who retires 1 July after 36 years at Wayne.

Recent Deaths

RUSSELL O. BREW, Haddonfield, N.J.; 47; engineer and specialist in photographic problems for the Radio Corporation of America; 23 Apr.

VEZEAUX DELAVERGNE; retired head of the department of bacteriology of the medical faculty of the University of Nancy; 21 Mar.

FRIEDA FROMM-REICHMANN, Rockville, Md.; 67; senior consultant and director of psychotherapy at the Rockville Sanitarium; 28 Apr.

EDGAR T. HOLMBERG, Cleveland, Ohio; 72; retired vice president of the Herron Testing Laboratories, Inc., who formerly had been a chemical engineer and chief chemist for the company; 25 Apr.

JOHN G. KERR, Barley, England; 87; zoologist who originated "dazzle" camouflage painting in World War I; former Regius professor of zoology at Glasgow University; 24 Apr.

ARTHUR S. KING, Pasadena, Calif.; 81; retired physicist who headed the physics laboratory at Mount Wilson Observatory from 1908 to 1943; member of the physics staff at California Institute of Technology for 2 years during World War II; mathematician with the Naval Ordnance Test Station at Pasadena until 1954; 25 Apr.

SIR MURDOCH MACDONALD, Nairn, Scotland; 91; consulting civil engineer who designed the original Aswan Dam in Egypt; 24 Apr.

GERARD MONTUS, Geneva, Switzerland; 82; deputy director of the European Regional Office of the World Health Organization; 21 Apr.

BRUCE D. REYNOLDS, Charlottesville, Va.; 62; chairman of the department of biology at the University of Virginia and former director of the Mountain Lake Biological Station; representative of the Association of Southeastern Biologists on the AAAS Council, 1953–55, and member of AAAS Resolutions Committee, 1955; 26 Apr.

PAUL SETTLAGE, Madison, Wis.; 45; professor of anatomy at the University of Wisconsin; 20 Apr.

EDMOND N. SKINNER, Point Pleasant, N.J.; 81; retired mining engineer who spent 40 years with the Hayden Stone Company of New York; 27 Apr.

Reports

Dielectric Properties of the Membrane of Lysed Erythrocytes

The dielectric properties of the (plasma) membrane of normal erythrocytes are frequency independent at frequencies below 10 kcy/sec. (*1*). On the other hand, the properties of the membrane of hemolyzed erythrocytes have been reported to change with frequency in the range from 500 cy to 100 kcy/sec (*2*). Data available at the beginning of the present investigation (*3*) were not adequate to determine whether this frequency dependence extended over many octaves, as anticipated from a study of a (plasma) membrane whose dielectric properties change as a power function of frequency (*4*), or whether it is limited to a smaller frequency spectrum similar to that reported by one of us in the case of muscle cells (*5*).

For these reasons, it was decided to measure the capacitance C (in micromicrofarads) and resistance R (in ohms) of suspensions of hemolyzed erythrocytes, extending the range of observation to frequencies as low as possible. As a first step, cells hemolyzed with distilled water were investigated. Heparinized fresh beef blood was washed with Ringer Tyrode at *p*H 7.6 and centrifuged to high cellular volume concentration. The erythrocytes were resuspended in triple their volume of distilled water. Measurements were carried out at 25°C and evaluated under precautions previously summarized (*1*). Figure 1 shows the results obtained from one typical experiment. The points represent individual measurements.

If the dispersion arises from a relaxation process with a single relaxation time $T = 1/2\pi f_0$, it must be possible to represent the data by the following relationships:

$$C = C_\infty + \frac{C_0 - C_\infty}{1 + (f/f_0)^2};$$

$$R = R_0 - (R_0 - R_\infty)\,\frac{(f/f_0)^2}{1 + (f/f_0)^2}$$

where C_0, C_∞ and R_0, R_∞ are the low- and high-frequency limits of the capacitance and resistance, and f_0 is the relaxation frequency determined by the magnitude of the dispersion of resistance and capacitance as follows:

$$R_0 - R_\infty = 2\pi f_0\,(C_0 - C_\infty)\,R_0 R_\infty$$

The derivation of these equations is based only on the assumptions of linearity and exponential response of polarization to a step-function potential. Introducing the measured values of $R_0 - R_\infty = 1.18$ ohm and $C_0 - C_\infty = 34$ μμf, we determine $f_0 = 1.9$ kcy/sec. The curves corresponding to these parameters have been drawn as solid lines in Fig. 1. Agreement between measurement and theory is seen to be as exact as measurements could be obtained: resistance, ±0.001 percent; capacitance, ±[1/*f* (kcy/sec) ±0.5] percent).

The results obtained do not depend on current strength, and thus they characterize the passive behavior of the lysed erythrocyte suspension. The capacitance of the (plasma) membrane, as calculated from the present data above 10 kcy/sec, is about 0.9 μf/cm² of surface. The dielectric constant of the solution is almost completely controlled by the contributions of the (plasma) membrane. Hence, the dispersion in the capacitance reflects proportionally a dispersion in the capacitance of the membrane itself.

The magnitude of the resistance of the suspension, on the other hand, is controlled largely by the suspending fluid, and the dispersion caused by the presence of the membranes is a very small fraction of the total resistance. Hence, it is impossible to compute the resistance of the membrane in the same manner as is possible to compute the capacitance. However, the low frequency dispersion reported here establishes an upper limit of the membrane resistance above 10 kcy/sec. If the membrane were a perfect insulator at low frequencies (below 100 cy/sec), it follows from membrane capacitance and ratio of total conductance and capacitance change that the resistance of the membrane above 10 kcy/sec is 100 ohm-cm².

The phenomenon of frequency-dependent dielectric properties of the (plasma) membrane of hemolyzed erythrocytes, as demonstrated, proves that biological interfaces do not necessarily behave in the manner predicted by polarization theory (*4*). The exact nature

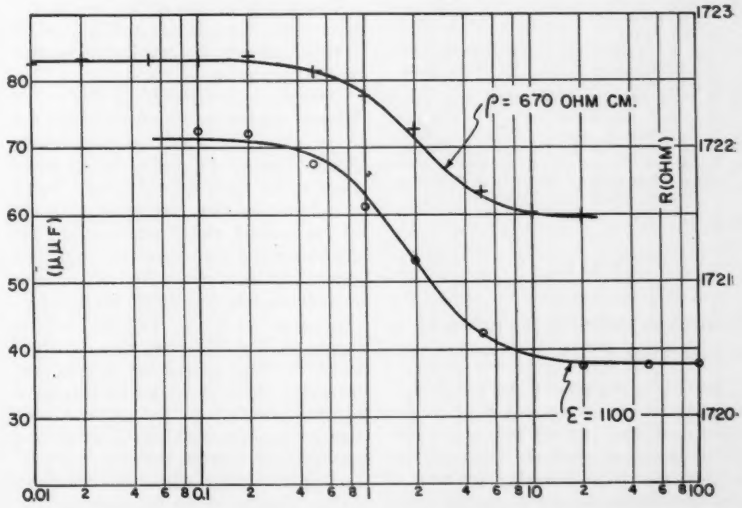


Fig. 1. Frequency dependence of capacity in micromicrofarad and resistance in ohm of lysed erythrocyte suspension. Frequency in kilocycles per second; dielectric constant $\varepsilon = 1100$ above 10 kcy/sec; specific resistance $\rho = 670$ ohm-cm.

All technical papers and comments on them are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table *or* one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

of the processes underlying the reported relaxation effect is not yet clear. The effect is similar to the relaxation process reported previously in muscle tissue (*5*), except for a time constant which is about one-twentieth as large as that for blood and about 0.1 msec. The effect may be indicative of a double-layer structure of the ghost envelope due to two different molecular components of different dielectric losses (*6*).

Even more likely is the existence of a mechanism which restricts ion exchange across the membrane and which necessitates about 0.1 msec to become effective. The fact that similar relaxation effects could not be observed in normal cell suspensions (*1*) could be related to an increase in permeability in the case of hemolyzed cells and consequent shift of the relaxation spectrum from frequencies too small to be investigated up to the range demonstrated. The simple frequency dependence of the membrane properties of lysed cells reported here and of muscle cells reported previously (*5*) makes it necessary to differentiate between "static" and "dynamic" permeability values, the former applying to long-time, and the latter to short-time, stimuli, and with the transition characterized by a single rate constant in the case reported in this article.

H. P. Schwan
E. L. Carstensen
Electromedical Division, Moore School of Electrical Engineering, and School of Medicine, University of Pennsylvania, Philadelphia

References and Notes

1. T. P. Bothwell and H. P. Schwan, *Nature* 178, 265 (1956); T. P. Bothwell, H. P. Schwan, F. J. Wiercinski, *Federation Proc.* 13, No. 1 (1954).
2. H. Fricke and H. J. Curtis, *J. Gen. Physiol.* 18, 821 (1935).
3. This investigation was supported by the National Institutes of Health, U.S. Public Health Service, grant H-1253 (C3).
4. H. Fricke, *Physics* 1, 106 (1931); K. S. Cole, *Science* 79, 164 (1934).
5. H. P. Schwan, *Z. Naturforsch.* 9b, 245 (1954).
6. E. N. Harvey and J. F. Danielli, *Biol. Revs. Cambridge Phil. Soc.* 13, 319 (1938); H. Davson and J. F. Danielli, *Permeability of Natural Membranes* (Macmillan, London, 1943).

18 January 1957.

Suspension Counting of Carbon-14 in Scintillating Gels

Several techniques have been described for the incorporation of weak alpha and beta emitters into a scintillation counting medium in order to achieve the high detection efficiency, short resolving time, and energy-discrimination facilities which are inherent in scintillation counting methods. These techniques have included direct solution in an organic medium (*1*), the use of inorganic salts in water-dioxane solutions (*2*), the syntheses of nonquenching solvents (*3*), and the use of quaternary ammonium salts (*4*). Hayes (*5*) described the counting of tagged materials in suspension in liquid scintillators. The disadvantage of rapid settling of the suspended material inherent in this method was overcome by the use of scintillating gels as described by Funt (*6*) and more recently by White and Helf (*7*). In this article we report an investigation of the counting efficiencies of scintillating gels in the estimation of C^{14} and their dependence on the concentration and specific activity of the suspended material.

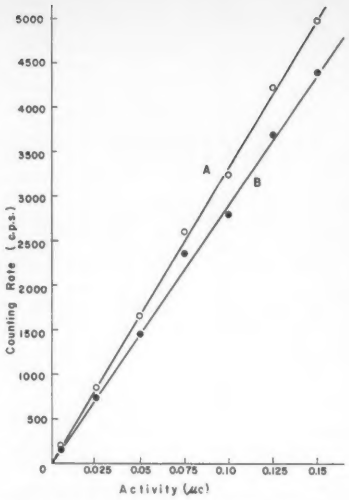


Fig. 1. Linear dependence of counting rate on activity with fixed weight (0.1770 g) of suspended $BaCO_3$ in 10 ml of gel. Curve *A* was obtained with 1.5 kv on the photomultiplier tube, curve *B* with 1.4 kv.

Samples containing $BaC^{14}O_3$ of known specific activity were prepared from active Na_2CO_3, obtained from Atomic Energy of Canada Limited. Scintillating gels were formed from a liquid scintillator solution containing 4.0 g/lit of *p*-terphenyl and 0.1 g/lit of 1,4-bis 2,5-phenyloxazolyl benzene (POPOP) (*8*). To this solution, 70 g/lit of aluminum stearate was added for the formation of rigid gels, and the desired weight of $BaC^{14}O_3$ was then incorporated. A 10-ml scintillator volume was used, and the precipitate was dispersed uniformly throughout the colloidal solution by vigorous shaking. Gelation was produced by inserting the glass vial containing the suspension into water at 80°C. Vials 22 by 10 cm were used in the preparation and measurement of the samples. The vials were surrounded by MgO reflectors, and the corks were lined with aluminum foil for the counting experiments. They were bonded with silicone fluid to Dumont K1295 or K1190 photomultiplier tubes. The counting equipment consisted of a standard scintillation counting assembly, including cathode follower, Atomic 204 linear amplifier, constant voltage supply, Dynatron N/101 discriminator, and Tracerlab 105 scaler.

The linear dependence of counting rate on specific activity is illustrated in Fig. 1. For this experiment, a constant weight of $BaCO_3$ (0.1700 g) was suspended in 10 ml of the gel. In the range of specific activities from 0.005 to 0.150 μc, the counting rate was found to be linearly dependent on the activity. For the preparation of these samples, a constant volume of Na_2CO_3 solution, prepared from varying ratios of active and inactive Na_2CO_3 of the same molarity, was used. The tests were conducted with samples of high activity, and it was thus possible to set the discriminator to count all pulses greater than 4 v without unduly increasing the background and noise counting rate contribution. In Fig. 1, curve *A* was taken with a potential of 1.5 kv on a 1-inch K1190 photomultiplier tube mounted in a massive lead shield. Under these conditions, an average background counting rate of approximately 50 count/sec was obtained in a counting rate (corrected for background) of between 200 and 5000 count/sec. For samples of lower activity, it would be desirable to reduce the background count. A lower potential on the photomultiplier tube (1.4 kv) produced curve *B* with the same discriminator settings. In this instance, the background was reduced to approximately 18 count/sec. However, the over-all counting efficiency was reduced as a result of this drop in amplification, and a greater

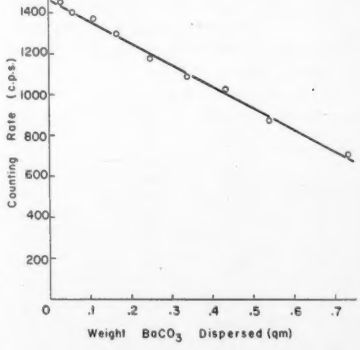


Fig. 2. Variation of counting rate with weight of suspended material at constant activity (0.05 μc).

Table 1. Optical transmittance of scintillating gels of aluminum stearate. I, transmitted radiant power; I_o, incident radiant power. The absorbance $A = abc$, where a is the absorptivity, b is the thickness of the cell, and c is the concentration in grams per liter.

Al stearate concn. (g/lit)	5000 A		4500 A	
	I_o/I	log I_o/I	I_o/I	log I_o/I
10	1.015	0.0064	1.029	0.0123
30	1.068	0.0286	1.092	0.0382
50	1.098	0.0407	1.128	0.0522
70	1.138	0.0561	1.178	0.0712

decrease would be inevitable if the discriminator bias were set higher in order to further reduce the background contribution for less active samples.

The variation of counting efficiency with total weight of precipitate at a constant specific activity is shown in Fig. 2. The samples were prepared from a fixed volume of active Na_2CO_3, mixed with varying volumes of inactive Na_2CO_3 of the same molarity. For this experiment a total activity of 0.05 μc was maintained in each sample. The counting data were obtained on a Dumont K1295 2-inch photomultiplier tube. The counting efficiencies dropped from 75.6 percent for 1 percent by weight of precipitate to 37.2 percent for 7.5 percent by weight of precipitate in these tests. The absolute counting efficiencies quoted are based on the stated activity of the Na_2CO_3 solution used, but the indicated accuracy of this source was ± 10 percent, and the calculated efficiencies may be in error by this amount. The effects of particle size and density were not investigated, but it seems obvious that settling and self-absorption effects would be reduced if a material of lower density than $BaCO_3$ (density 4.4) were used.

Some gels were formed in evacuated cells in order to eliminate the effects of oxygen quenching (*9*). An increase in pulse height and in counting efficiency was observed under these conditions. For example, the count of a sample containing 0.1665 g of $BaCO_3$ and 0.05 μc activity increased from 1360 to 1585 count/sec.

The optical transmission of the gels was also investigated. The thickened systems used by White and Helf (*7*) appeared to have poor transmittance as judged from the published photographs of their samples. The transmission characteristics of aluminum stearate gels were measured with a Beckman DK-1 recording spectrophotometer using 1-cm quartz cells. The data at 5000 and 4500 A are shown in Table 1.

The data of Table 1 yielded a linear Beer's law plot whose slope gave a value for the absorptivity a of 0.00082 lit/gm-cm at 5000 A and 0.00104 at 4500 A.

Settling effects were negligible after the first day. A sample containing 0.05 g of $BaCO_3$ gave identical results within experimental error after 3 weeks' standing.

These counting experiments indicate that the scintillating gel technique provides a simple and effective means of assessing the activity of beta and alpha emitters. High sensitivity, good reproducibility, and linearity of response with activity are observed over a useful range of suspended material. The method compares favorably with the new technique recently described by Passman, Radin, and Cooper (*4*). In the same scintillator volume, about 7 times as much carbon can be incorporated as by their CO_2 method. The counting efficiencies appear better than those recently reported by White and Helf (*7*) for scintillating gels. This may be due to the superior optical properties of the gels reported here, but much of the difference is undoubtedly due to the wider gate settings used in our discriminator. In comparison with other techniques for assaying C^{14}, (*10*), scintillating gels offer many advantages. The samples are readily stored, vacuum manifolds are not needed, and compounds can be measured directly without the necessity of combusting or destroying the sample. The over-all sensitivity is superior to that obtainable with most gas counting techniques, and pulse height discrimination can be employed when one is counting radiation of differing energy (*11*).

B. Lionel Funt
Arlene Hetherington
Chemistry Department,
University of Manitoba, Winnipeg

References and Notes

1. M. S. Raben and N. Bloembergen, *Science* 114, 363 (1951); G. T. Okita, J. Spratt, G. V. Leroy, *Nucleonics* 14, No. 3, 76 (1956); F. N. Hayes and R. G. Gould, *Science* 117, 480 (1953); B. N. Audric and J. V. P. Long, *Research (London)* 5, 46 (1952).
2. M. Furst, H. Kallmann, F. H. Brown, *Nucleonics* 13, No. 4, 58 (1955).
3. B. N. Audric and J. V. P. Long, *Nature* 173, 992 (1954); J. R. Arnold, *Science* 119, 155 (1954); B. L. Funt *et al.*, *Nature* 175, 1042 (1955); R. W. Pringle, W. Turchinetz, B. L. Funt, *Rev. Sci. Instr.* 26, 859 (1955).
4. J. M. Passman, W. S. Radin, J. A. Cooper, *Anal. Chem.* 28, 484 (1956).
5. F. N. Hayes, B. S. Rogers, W. H. Langham, *Nucleonics* 14, No. 3, 48 (1956).
6. B. L. Funt, *Nucleonics* 14, No. 8, 83 (1956).
7. C. G. White and S. Helf, *Nucleonics* 14, No. 10, 46 (1956).
8. F. N. Hayes, B. S. Rogers, D. Ott, *J. Am. Chem. Soc.* 77, 1, 850 (1955); F. N. Hayes, D. G. Ott, V. N. Kerr, *Nucleonics* 14, No. 1, 42 (1956).
9. R. W. Pringle *et al.*, *Phys. Rev.* 92, 1582 (1953); B. L. Funt and E. Neparko, *J. Phys. Chem.* 60, 267 (1956); P. J. Berry, S. Lipsky, M. Burton, *Trans. Faraday Soc.* 339, 52, 311 (1956); H. H. Seliger, C. A. Ziegler, I. Jaffe, *Phys. Rev.* 99, 663 (1955); 101, 998 (1955); M. Burton, P. J. Berry, S. Lipsky, *J. chimie phys.* 52, 9 (1955).
10. C. D. Wagner and V. P. Guinn, *Nucleonics* 13, No. 10, 56 (1955).
11. We express our appreciation to the National Research Council and to Imperial Oil Limited for financial assistance for part of this work. We are also indebted to Nuclear Enterprises Limited of Winnipeg, Canada, for the supply of scintillation chemicals and technical assistance with some of this work.

18 February 1957

Potentially Simple Technique for Rearing "Germ-Free" Fish

"Germ-free" animals, those deprived of detectable microorganisms, are highly useful for studies in nutrition, disease, infection, and immunity. Investigators who have felt the need for this type of animal for the past 50 years have encountered many difficulties because rearing germ-free animals is a laborious and complicated procedure. Many complex techniques are involved, the necessary equipment is elaborate and costly, and the animals require careful and constant attention (*1*).

In the course of some experiments on the role of oral incubation in the cichlid fish, *Tilapia macrocephala*, L. R. Aronson and I (*2*) discovered that dipping fish eggs into a 0.04-percent formaldehyde-aquarium water solution for 10 minutes resulted in germ-free eggs which, when transferred aseptically to sterile water, grew into germ-free fry. Of 25 trials (consisting of 10 eggs per trial) treated in this manner (*3*), eight trials remained germ-free died during the experiment, Those embryos which did not remain germ-free died during the experiment, since certain of the bacteria proved to be lethal contaminants (*2*). The germ-free embryos, however, survived for 2 to 3 weeks after hatching, using the large quantity of yolk as their source of food. When these fry eventually died of starvation after the yolk was absorbed, they did not disintegrate. Some of the dead fish were kept as long as 4 months, when they were discarded. No microorganisms could be cultured from a number of the dead fry when culture was attempted in Difco nutrient broth, Difco nutrient agar, and thioglycollate media. Likewise, no mold and fungal growths were detected.

Since this problem is not related to the work of the department of animal behavior, it was not pursued, but the observations suggest that *Tilapia macrocephala* could be fed aseptically and brought to germ-free maturity in an appropriately equipped bacteriological laboratory with fewer of the complications that are encountered in other forms. For example, Baker and Ferguson (*4*) found

that germ-free platyfish, *Xiphophorus maculatus,* required live food for their maintenance. This caused many technical difficulties and led to inadequate growth. *Tilapia macrocephala,* on the other hand, are regularly raised on dried food, which can be sterilized easily, and preliminary tests indicate that the dried food does not lose its nutritive properties when it is autoclaved. In addition, fertile eggs are available in large numbers, for the adults reproduce during the entire year at frequent intervals. Many fish can be raised together, they require little care, and the environment can be kept reasonably uniform. What is still needed is a simple device whereby the fish can be fed and whereby gases can be exchanged aseptically.

EVELYN SHAW
Department of Animal Behavior, American Museum of Natural History, New York, New York

References and Notes

1. J. L. Reyniers, *Lobund Repts. No. 1* (1946); *No. 2* (1949).
2. E. S. Shaw and L. R. Aronson, *Bull. Am. Museum Nat. Hist.* 103, 379 (1954).
3. I wish to thank Joel Rodney and Stephen Levine for their technical assistance.
4. J. A. Baker and M. S. Ferguson, *Proc. Soc. Expt. Biol. Med.* 51, 116 (1942).

12 February 1957

Concerning the "Cellularity" or Acellularity of the Protozoa

Most protozoologists (*1*) probably will agree with Alan Boyden's recent contention (*2*) that it is logical to consider protozoa as "cellular" organisms (that is, cells). In fact, over 40 years ago, Minchin (*3, 4*) defended this notion well, shortly after the appearance of Dobell's vigorous attack (*5*) on the cell theory and its implications concerning the nature of protozoa. However, the recent outburst of criticism directed at Dobell and Hyman (*6*) by Boyden seems rather harsh and narrow. Neglected entirely, furthermore, was consideration of the fundamental question of how, precisely, a cell may be defined; until an entirely satisfactory answer to this question is available, it may be as improper to insist dogmatically that protozoa are unicellular as to claim that they must be noncellular. It is the purpose of the present comment to show that the whole problem is considerably more complicated than Boyden has indicated.

C. G. Ehrenberg (*7*), many years ago, championed the notion that protozoa are "vollkommene Organismen." But, as a consequence of F. Dujardin's exposure (*8*) of the fallaciousness of his contemporary's *morphological* observations, many biologists came to think of the protozoa as simple and as comparable with a single metazoon only when the physiologic (or sexual) life cycle of an entire clonal population was considered. In the light of the atmosphere of the period in which Dobell wrote his trenchant essay, he deserves credit for focusing fresh attention on the fundamental truth of Ehrenberg's idea: in general a *single* protozoon is as capable of independent locomotion, feeding, growth, reproduction, regeneration, and so on, as is any *entire* metazoan organism.

Neither Dobell nor Hyman directly denied the essential homology of nuclei and various cytoplasmic structures that are possessed in common by metazoan cells and the protozoa, since they admitted that the same fundamental organization is to be found in members of both groups. In their insistence that an individual protozoon is, also, homologous with an entire multicellular organism, I think perhaps the only serious breach of logic is the use of the word *homologous* (which is employed directly in this connection, incidentally, only by Dobell). As Minchin (*4*) observed, "the view generally held that the entire organism of a Protozoon is truly homologous with a single body-cell of a Metazoon seems to me quite unassailable. . . . On the other hand, any Protist, as an organism physiologically complete in itself, is clearly analogous to the entire individual in the Metazoa—a comparison, however, which leaves the question of genetic homology quite untouched."

What is a cell? Although it would be inappropriate to offer a lengthy treatment of the question here, we must consider the matter to some extent. Dobell added to the well-known classical definition of the cell the qualification that it "is a part of an organism and not a whole organism." Thus, his insistence that protozoa are noncellular represents a stand not at all inconsistent or illogical, it seems to me, with respect to his own definition of a cell. Minchin himself, Dobell's most outstanding critic, suggested (*4*): "So long as the Protozoa are studied entirely by themselves, without reference to any other forms of life, they may be termed non-cellular in the sense that they are not composed of cells." Hyman also described a cell as "one nucleated division of an organism" (but compare *9*). One must acknowledge that adherents to the definition (be it good or poor) proposed by Dobell and Hyman are placed in an uncompromising position: protozoa are not parts of organisms and thus cannot be cells. The several workers (for example, Lwoff, *10*) on the physiology of protozoa who presumably adopted the acellularity concept may well have been accepting the spirit, only, of Dobell's interpretation in order to emphasize the striking similarities in the biochemistry of the individual protist and the entire metazoan animal.

Nearly a decade ago, J. R. Baker (*11*) criticized Dobell's ideas quite strongly, yet he offered an original definition of a cell ("a mass of protoplasm, largely or completely bounded by a membrane, and containing within it a single nucleus formed by the telophase transformation of a haploid or diploid set of anaphase chromosomes") which, on his own admission, obliges one to consider all "polyenergid" protozoa, including the ciliates, as noncellular organisms. To follow Baker, one would have to recognize both unicellular and acellular forms; the distinction would be dependent solely on the number of nuclei present.

Some biologists have suggested that certain protozoa are truly multicellular in their organization. G. S. Carter's discussion (*12*) is particularly pertinent: he calls attention to the cnidosporidian *Myxobolus,* in which several somatic cells are observable at one stage in the life cycle, endowing the organism with genuine multicellularity.

Thus, it need not be considered altogether illogical to think of the protozoa as comprising a variety of forms some of which are clearly only unicellular, others multicellular in certain stages, still others acellular throughout their lives. Personally, however, I favor rejection of the circumscribed definitions of a cell offered by both Baker and Dobell, and I consider the protozoa, as a group, to be unicellular organisms (not necessarily animals). But the dangers associated with such a generalization should always be kept in mind. A single protozoon is a whole individual—more than the equivalent of a component, dependent part (cell) of a highly integrated multicellular organism. In spite of its morphologic homology with a dissociated cell of the metazoan body, it often possesses an unparalleled degree of subcellular differentiation. Physiologically, as well as morphologically, the majority of the protozoa are independent, complex organisms, far from simple in spite of their typically microscopic size.

JOHN O. CORLISS
Department of Zoology, University of Illinois, Urbana

References and Notes

1. Among 20 postwar publications, including textbooks in the field from five foreign countries, which treat all the protozoa, or a particular group, or some major aspect of protozoology, only three strongly favor the acellularity concept.
2. A. Boyden, *Science* 125, 155 (1957).
3. E. A. Minchin, *An Introduction to the Study of the Protozoa* (Arnold, London, 1912).
4. ——, *Brit. Assoc. Advance. Sci. Rept.* 85, 437 (1915); reprinted in *Am. Naturalist* 50, 5, 106, 271 (1916).

5. C. C. Dobell, *Arch. Protistenk.* **23**, 269 (1911).
6. L. H. Hyman, *The Invertebrates: Protozoa through Ctenophora* (McGraw-Hill, New York, 1940).
7. C. G. Ehrenberg, *Die Infusionsthierchen als vollkommene Organismen* (Leipzig, 1838).
8. F. Dujardin, *Histoire naturelle des Zoophytes Infusoires* (Paris, 1841).
9. Although Hyman considered the protozoa as acellular throughout her treatment of them as invertebrates, she employed the term "unicellular" in the title of a paper published 2 years later [L. H. Hyman, *Biol. Symposia* **8**, 27 (1942)].
10. A. Lwoff, *Biochemistry and Physiology of Protozoa* (Academic, New York, 1951).
11. J. R. Baker, *Nature* **161**, 548, 587 (1948).
12. G. S. Carter, *A General Zoology of the Invertebrates* (Sidgwick and Jackson, London, 1946).

4 February 1957

Alan Boyden's (*1*) strictures on an "unwise" attack on the cell theory by Dobell, Hyman, and Lwoff, and by us, are symptomatic of a malaise that is afflicting research on the organization of cellular animals. Comment therefore is in order.

J. R. Baker (*2*), in an exhaustive analysis of the vicissitudes of the cell theory, set forth his understanding of the essentials of the cell theory in the form of seven propositions, to which we adhere (with reservations on numbers 3 and 7). The italics are ours in the following abbreviated restatement of Baker's propositions:

1) Most organisms contain or consist of a large number of cells.

2) Cells have essentially the same nature and are units of structure.

3) Cells arise, directly or indirectly, from preexisting cells.

4) Cellular organisms consist of nothing except cells, transformed cells, and material extruded by cells and by transformed cells (except that in some cases water, with its dissolved substances, is taken directly from the environment into the coelom or other intercellular spaces).

5) Cells are *to some extent* individuals, and there are therefore two grades of individuality in most organisms: that of the cells, and that of the organisms as a whole.

6) Each cell of a many-celled organism corresponds *in certain respects* to the whole body of a simple protist.

7) Many-celled plants and animals probably originated by the adherence of protist individuals after division.

Boyden states that "because of their essential [*sic*] correspondence part for part with the cells of Metazoa, Protozoa are undoubtedly cellular," and thereby begs the question. Later, he says: "Dobell wished to emphasize that an individual protist could act as an individual metazoan, which within limits is true." What "limits"? We fail to see them. Boyden imputes to us "the denial of the essential homologies that exist in all cells." We consider that protozoa are homologous in their general structure to the cells of metazoa but that they have the autonomy of the whole organism. We contend, therefore, that it is necessary to be clear about where the homology of cell to cell ends and where the homology of cell to organism starts. The term *acellular* was coined to avoid an unwarranted extension of the cell theory to protists. We regret that a less tendentious word was not coined; *unicellular* is even less satisfactory. In order not to coin words for this situation, it seems best—and simplest—to put the emphasis on protozoa vis-à-vis metazoa, and to avoid altogether the use, for protozoa, of adjectives containing the term *cell*.

Baker sets the dispute in historical perspective by pointing out that the disagreement about the cell theory has mainly involved two extensions of the original cell theory: (i) that the cell of the many-celled organisms are homologous with the individual protists; and (ii) that this is an essential part of the cell theory. Baker's propositions 5 and 6 amount to a rejection of (i) and (ii). Samuel Butler's epigram, "a hen is an egg's way of making more eggs," is defensible. But emphasis on cell over organism leads to an untenable position: "an organism is a cell's way of making more cells." Patently, this is a fallacy of the cart-before-the-horse variety.

The crucial problem is the *something* which is responsible for the integrity of the organism: can it be homologized with any cell or part of a cell? No indeed. The central problem of embryology is that of differentiation, with its concomitant loss of totipotency (the capacity to form an organism). R. B. Goldschmidt (*3*) concurs in the opinion of Paul Weiss that "the most difficult and most neglected of all basic fields of morphogenesis [is] that of supercellular integration." Hence our italics in propositions 5 and 6.

The malaise to which we refer is a disinclination to face up to the problem of the prerequisites for cellular existence. For example, cancer is a unique disease of cellular organisms. Yet, despite this prod, we are ignorant of the essential, deep-seated coordinations among cells. The newcomer to biology might suppose that the lower metazoa would be favorite objects of investigation, for here one might expect to find these ties in their quintessential and most accessible form. The research scene is depressingly different: the workers engaged in analyzing, in chemical terms, the cellular differentiations of coelenterates and flatworms (and, for that matter, sponges) are all too few. (Boyden is not the object of this remark; he has been working on the organization of *Hydra*.) We have argued (*4*) that this neglect means a stultification of the comparative side of protozoology: how can the hormones of vertebrates and arthropods be traced with assurance to their origins, perhaps as far back as the protozoa or other protists, if information is almost wholly lacking for the lower metazoa? Boyden says that "there may have been a time when the complexity of some [*sic*] protozoans and the integration of the metazoan individual were underestimated"; alas, that time is still now—a fact that is witnessed by the near-total lack of progress on the problem of the origin of any hormone and of the mode of action of any hormone on the target cell (*5*). To dwell on the well-established homologies of cells while playing down their differentiations and interdependencies hardly seems helpful in tackling the problem of the fundamental basis of cellularity.

Furthermore, rigid adherence to 19th century cell theory has hindered medical research as well. Thus, J. H. Kellgren states (*6*):

"After the introduction of the cell doctrine by Schwann in 1819, it became customary to think of the human body as a mass of living cells. Though there is much truth in this concept, it is only half the truth, since more than half the body is composed of extracellular material. . . . Although collagen and elastic fibres were characterized histologically and, to some extent, chemically during the nineteenth century (Hollett, 1871), the personality of Virchow and his dictum, '*Omnis cellula e cellula*,' remained dominant, and the extracellular framework was regarded as so much inert stuffing that could have little bearing upon the problems of health and disease. It was not until 1933, when Klinge showed that alterations in the intercellular substances were the most striking feature of certain rheumatic diseases, that interest in these substances was reawakened, and since then the concept of collagen diseases (Klemperer, 1950) or connective tissue diseases (Kellgren, 1952) has received increasing attention, and it has even been suggested that the state of the extracellular ground substance may control cellular activity (Gersh, 1950)."

Protozoa are organisms first, with some homologies to cells.

S. H. Hutner
L. Provasoli
Haskins Laboratories, New York, New York

References

1. A. Boyden, *Science* **125**, 155 (1957).
2. J. R. Baker, *Quart. J. Microscop. Sci.* **89**, 103 (1948).
3. R. B. Goldschmidt, *Theoretical Genetics* (Univ. of California Press, Berkeley, 1955).
4. S. H. Hutner, "Introduction," *Biochemistry and Physiology of Protozoa* (Academic, New York, 1955), vol. 2.
5. D. Hechter, *Vitamins and Hormones* **13**, 293 (1955).
6. J. H. Kellgren, *Lectures on the Scientific Basis of Medicine* (Athlone, London; De Graff, New York, 1955), No. 3, p. 78.

20 February 1957

In answering the question "Are there any 'acellular animals'?" in the negative, Alan Boyden (*1*) refers to the cell theory as one of the greatest generalizations of biology. Certainly it has been, and is, of the utmost importance in the very extensive areas where it is relevant. But any successful generalization carries within itself the potential capacity to become a dogma. When that happens, it may well serve as a Procrustean bed into which unhappy facts, if they do not fit properly, must be forced by violence. I wish to call attention to one fact of organization that can be fitted into the cell theory only by such violence.

A large myxomycete plasmodium may contain millions of nuclei imbedded in a common matrix. At its advancing margin, such a plasmodium is essentially naked, bordered only by an ectoplasmic layer from which delicate pseudopodia may extend. The remaining portions, and particularly the veins that are usually its most conspicuous elements, are surrounded by a thick, gelatinous, enucleate sheath, within which the enclosed nucleate protoplasm circulates, and which collapses and is left behind on the substratum as the plasmodium advances. How may such a structure be forced into the cell theory? Two attempts have been made.

One, repeated many times, refers to such a mass as a single, multinucleate cell. As anyone who has cultured plasmodia knows, it may break up into two or a dozen smaller plasmodia, which may combine again in any possible degree. A large plasmodium, cultured in a Wardian case, may cover an area of half a square meter; there is good evidence that, in nature, it may be much larger. If this is to be regarded as a single cell, it must carry with it into the cell theory the concept of an enormous cell that may break up into numerous smaller, but still relatively enormous, cells that may re-fuse into larger units in a sequence that may be repeated an indefinite number of times until it is interrupted by fruiting. To call such a structure a cell seems to go far toward destroying the usefulness of the cell theory in areas where it is really important.

Another suggestion, less popular but not infrequently invoked, is that a myxomycete plasmodium is a multicellular organism in which each cell is represented by an individual nucleus and that portion of the surrounding cytoplasm that may be assumed to be under its influence at any particular instant. Examination of the flow in a plasmodial vein under a moderately high power objective demonstrates that there is no constant relationship between a nucleus and its surrounding protoplasm. This is evidenced by the relative movement of nuclei and visible extranuclear granules borne in the same stream. Such an explanation, then, is purely idealistic and quite completely divorced from observable fact.

It is, of course, recognized that the swarm-cells, which often function as gametes, the zygotes, and the spores of Myxomycetes may legitimately be regarded as cells. But this does not affect the argument for regarding the organization of plasmodia as acellular. Such recognition, it is true, carries further implications. If plasmodia are to be called acellular, what is to prevent one from taking seriously the arguments that have been advanced with respect to the lack of cell organization in mucors and numerous other fungi? Discussion of this problem goes beyond the scope of these comments, but its existence should be noted.

G. W. MARTIN

Department of Botany,
University of Illinois, Urbana

Reference

1. A. Boyden, *Science* **125**, 155 (1957).

4 February 1957

I am pleased that my simple question, "Are there any 'acellular animals'?" has resulted in the expression of opinions both favorable and unfavorable, because there are larger issues involved than the immediate answer to the question. My brief report and the three replies could provide an interesting study in biological thinking.

J. O. Corliss agrees with me in considering the protozoa, as a group, to be unicellular organisms. "But the dangers associated with such a generalization always should be kept in mind." My view is that the dangers of denying this generalization are far greater than those of accepting it. For this is primarily a question of homology, and if, as is generally admitted, the body of the individual protozoan corresponds, part for part, with the individual cells of metazoa, then we must refer to them all as "cellular" (or as "acellular"). The history of our terminology is such that we are required to use the term *cellular* for such protoplasmic organization, and a decent respect for our heritage of words would confirm us in this usage.

It is granted that precise definitions are desirable, but the trouble is that nature presents us with so many variations on a central theme that precise definitions are difficult. The more important capacity is to recognize the central theme —in this case, the general pattern of protoplasmic organizations commonly referred to as "cellular." Only a fundamentally different pattern of organization should be called "acellular," but there is no such difference in organization between the gametes and zygotes, between the zygotes and subsequent stages of metazoa, or between any of these cells and individual protozoa.

The matters raised by S. H. Hutner and L. Provasoli are important in themselves, but I do not agree with them in the belief that progress in the understanding of problems of differentiation and integration requires us to consider protozoa acellular or to believe that cellular stages arise out of acellular stages in metazoan ontogeny. All protoplasmic systems are organized, and there is surely some virtue in accepting this fact as we search for the new truth.

As to the points raised by G. W. Martin, they do not, in my opinion, destroy the validity of the generalization that animals are cellular. There may always be differences of opinion in regard to whether certain plasmodia are unicellular or multicellular, but they remain *cellular* for all that. If fundamentally different kinds of protoplasmic organization in animals should be found, they might become of great interest from the standpoint of primitive evolution, but the cell theory would still stand.

ALAN BOYDEN

Department of Zoology, Rutgers
University, New Brunswick, New Jersey

13 March 1957

Magnetometer Method for Recording Gastric Motility

Although human gastric motility has been recorded for many years, all accepted methods to date, other than roentgenographic, require the subject to swallow the sensing element with its attached tube or wires issuing from the mouth or nose. These leads constitute a marked and relatively persistent noxious stimulus. One of us (M. A. W.) has searched for many years for a practical, bland technique for continuous remote recording of stomach action. With the assistance of many people (*1*) we have devised such a technique (*2*).

The subject needs only to swallow a magnet about the size of a vitamin capsule and then recline on a cot. A detector placed beneath the wooden cot about 18 inches below the subject's stomach senses the field variations resulting from the magnet's presence and motion and translates them into electric variations which are then amplified and recorded. Although a program of direct validation by motion-picture fluoroscopy plus the simultaneous use of a gastric balloon is not complete, the frequencies and relative amplitudes of the recorded waves seem to correlate well with previous results.

Although there are a number of magnetometer and metal-detection systems available, the unit we first used was a Waugh magnetometer type W-2, which was produced during World War II to bench-check steel aircraft components for residual magnetism. It required minor modifications for working into the chopper input of an Offner model D electroencephalograph. The detector responds to the absolute intensity of a steady magnetic field in a particular direction and will register zero when oriented in a plane perpendicular to the direction of the ambient field. The system is calibrated by measuring the effect of rotating the pickup a given amount about a vertical axis from its null point with respect to the earth's field. The field to which the instrument is responding for calibration is presumed to be the product of the horizontal intensity and the sine of the angle of displacement. On the basis of the published value of 0.25 gauss (*3*) for the horizontal intensity of the earth's field in California, 0.2 mgauss/cm of pen travel seems to be ample over-all sensitivity, the periodic field variations with motility present characteristically approaching 1 mgauss peak to peak.

The magnets used are 3/16-inch diameter by ½-inch long General Electric Company sintered alnico-5 rods furnished cut to length. These magnets are not treated in any special way to increase or preserve the degree of magnetization they have when received. They are prepared for ingestion by coating with polystyrene. Subjects report neither awareness of them after ingestion nor any kind of after effect, and the data (*4*) indicate that the ingested magnet probably remains within the stomach of most subjects for periods of 2 hours or longer. The field variations recorded can be shown to be a function not only of periodic amplitude of magnet movement, but of mode of motion, orientation, and position with respect to the detector.

The method appears to have many uses beyond the recording of stomach motility. For example, it is currently being used to detect particular patterns of movements in small laboratory animals; the magnets are fixed under the skin. The Waugh type W-2 magnetometer has been modified and improved by the current manufacturers (*5*) and by William T. Kyle, Electronic Facility, College of Engineering, University of California, Los Angeles. Information concerning the improved circuit we now employ may be obtained from Kyle until it is published.

M. A. Wenger
E. B. Henderson
J. S. Dinning

Department of Psychology, University of California, Los Angeles

17 MAY 1957

References and Notes

1. Individuals too numerous to mention have contributed to discussions of this problem. John Dinning of the UCLA College of Engineering is to be credited with suggesting the successful solution.
2. This project was supported in part by USPHS grant M788.
3. U.S. Coast and Geodetic Survey data of 1911–12.
4. M. A. Wenger, B. T. Engel, T. L. Clemens, *Am. Psychologist* 10, 452 (1955).
5. Irwin Laboratories, 1238 S. Gerhartane, Los Angeles 22, Calif. E. M. Irwin holds U.S. patent No. 2418553 on the detector unit.

4 February 1957

Stigmasterol in Cigarette Smoke

The presence of phytosterols in tobacco leaf (*1, 2*), seed (*3*), and smoke (*4*) has been previously reported; in only one case was a structure assigned to the sterol, that of γ-sitosterol isolated from *Nicotiana tabacum* (*2*). We wish to report the isolation of stigmasterol, a compound whose melting point differs from that of the other sterols recorded, from cigarette smoke (*5*).

The smoke generated from regular size, American, blended cigarettes was fractionated as we have described earlier (*6*). Fraction M (200 g) was chromatographed on silica gel; a mixture of 84 percent benzene and 16 percent ether eluted material whose infrared spectrum had absorption bands in the 9 to 11-μ region similar to those of many sterols (*7*). These bands were used to guide further isolation work. Fractional recrystallization from 1/1 benzene and methanol was followed by three chromatographies on acid-washed alumina, fractional recrystallization from 4/1 methanol and ethanol, and recrystallization from 1/4 benzene and petroleum ether (30° to 60°C), whereupon 35 mg of colorless crystals, mp 165.0 to 168.5°C, $[\alpha]_D^{20}$ – 40.2° (*8*) was obtained (stigmasterol, mp 170 to 171°C, $[\alpha]_D^{17}$ – 45.8° (*9*). The compound gave a positive Liebermann-Burchard test, and a precipitate with digitonin; it absorbed 2.0 moles of hydrogen (*10*) (assuming a molecular weight of 411); it exhibited a "false energy" maximum (*11*) at 206 mμ in the ultraviolet, ruling out the possibility of conjugated double bonds; and it had an infrared absorption spectrum consistent with that of stigmasterol. The reduction product had a melting point of 136.8 to 137.3°C $[\alpha]_D^{20}$ 25.3° {stigmastanol, mp 137°C (*12*), $[\alpha]_D^{20}$ 24° (*13*)}; its acetate melted at 131.2 to 132.4°C and had a rotation of $[\alpha]_D^{20}$ 16.2° {stigmastanyl acetate, mp 129.0 to 129.5°C $[\alpha]_D^{20}$ 15.4° (*14*)}; and its benzoate had a melting point of 135.0 to 136.0°C $[\alpha]_D^{20}$ 19.7° {stigmastanyl benzoate, mp 135.0 to 136.°C $[\alpha]_D^{20}$ 19.6° (*15*)}.

The acetate and the benzoate of the original sterol were prepared; the former, after several recrystallizations from 4/1 methanol and benzene, had a melting point of 140 to 141°C and a rotation of $[\alpha]_D^{20}$ – 51.9° {stigmasteryl acetate, mp 140 to 141°C $[\alpha]_D^{20}$ – 50.3° (*16*)}. It did not depress the melting point of an authentic sample of stigmasteryl acetate (*17*), and it had an infrared spectrum identical with that of the authentic material; the benzoate, after repeated recrystallization from 6/1 methanol and benzene, melted at 161.0 to 161.5°C $[\alpha]_D^{20}$ – 24.3° {stigmasteryl benzoate, mp 160.5 to 161.5° $[\alpha]_D^{20}$ – 24.5° (*18*)}.

The crude steroid fraction from fraction M contains other steroids which we have not as yet isolated in pure form. A sterol has also been obtained from fraction K (*6*); the data are: mp 149.5°C $[\alpha]_D^{20}$ – 63°, positive Liebermann-Burchard test; precipitate with digitonin; acetate, mp 137.0 to 138.0°C; benzoate, mp 124.5 to 125.0°C. The quantity isolated was too small for us to effect rigorous purification, and these values may be open to revision.

Khanolkar, Panse, and Divekar (*2*) found the sterol glycoside which they isolated from tobacco leaf to be readily hydrolyzed by dilute hydrochloric acid. The possibility therefore exists that, inasmuch as an acid extraction step was utilized in our fractionation of the cigarette smoke condensate, stigmasterol may be present in smoke in part, or in whole, as a glycoside. The quantity of sterol isolated corresponds to 0.5 μg per cigarette; this figure must be taken only as a lower limit inasmuch as considerable losses were sustained in the isolation process.

Alvin I. Kosak, James S. Swinehart, David Taber, Benjamin L. Van Duuren

Institute of Industrial Medicine, and Department of Chemistry, New York University, New York

References and Notes

1. F. T. Mosca, *Gazz. chim. ital.* 43, (II), 440 (1913); M. Kobel and C. Neuberg, *J. prakt. Chem.* 143, 29 (1935) (saponins); A. Shmuk, *Vsesoyuz. Inst. Tabach. i Makhoroch. Prom.* 133, 3 (1937); *Chem. Abstr.* 32, 4723 (1938) (fermented tobacco).
2. V. R. Khanolkar, T. B. Panse, V. D. Divekar, *Science* 122, 515 (1955).
3. C. Venkatarao *et al.*, *J. Indian Chem. Soc.* 20, 374 (1943).
4. O. Schürch and A. Winterstein, *Z. Krebsforsch.* 42, 76 (1935).
5. We are indebted to the American Cancer Society for a grant in support of this work.
6. A. I. Kosak, J. S. Swinehart, D. Taber, *J. Natl. Cancer Inst.* 17, 375 (1956).
7. K. Dobriner, E. R. Katzenellenbogen, R. N. Jones, *Infrared Absorption Spectra of Steroids* (Interscience, New York, 1953).
8. All rotations reported in this paper, whether taken from the literature or current work, were run in chloroform.
9. J. C. E. Simpson and N. E. Williams, *J. Chem. Soc.* 1937, 737 (1937).
10. Hydrogen uptake was rapid when a 5-percent rhodium on alumina catalyst was used but very slow in the presence of a platinum catalyst.

11. O. H. Wheeler and J. L. Mateos, *J. Org. Chem.* **21**, 1110 (1956).
12. D. Larsen and F. W. Heyl, *J. Am. Chem. Soc.* **56**, 2663 (1934).
13. H. Ichiba, *Sci. Papers Inst. Phys. Chem. Research (Tokyo)* **28**, 112 (1935).
14. S. Bernstein and E. S. Wallis, *J. Org. Chem.* **2**, 341 (1937).
15. D. Larsen, *J. Am. Chem. Soc.* **60**, 2431 (1938).
16. R. J. Anderson, *ibid.* **46**, 1450 (1924).
17. We are indebted to J. M. Chemerda for a sample of this compound.
18. A. C. Ott and C. D. Ball, *J. Am. Chem. Soc.* **66**, 489 (1944).

11 March 1957

Formation and Auxin Activity of Indole-3-Glycolic Acid

It is usually assumed that the plant growth hormone, indoleacetic acid, arises in plant tissue by some transformation of the amino acid tryptophan (*1*). This belief has become widespread despite the fact that the best yields in numerous enzymatic experiments have never exceeded a few percent (*2*). We therefore felt it necessary to examine other possible biosynthetic pathways for indoleacetic acid.

In view of the facts that tryptophan is known to arise in various biological systems via an enzymatic coupling of indole with serine (*3*) and that indole is known to couple also with D-glyceraldehyde-3-phosphate (*4*), we examined the possibility that indoleacetic acid or some close analog could arise by a direct union of indole with a two-carbon fragment. We found that indole and glyoxylate, in aqueous solution, reacted nonenzymatically to yield a Salkowski-positive compound later characterized as indole-3-glycolic acid (IGA, Fig. 1). This compound is active in several bioassays used for detecting auxins.

The reaction between indole and glyoxylate was carried out as follows. Aqueous solutions of indole and sodium glyoxylate (*5*) were mixed so that they contained 0.2 μmole of indole and 60 μmole of sodium glyoxylate in 1 ml of solution. After the mixture had been incubated for 1 hour at 30°C, residual indole was extracted with toluene and assayed by a method similar to that described by Yanofsky (*6*). Under the conditions described, approximately 25 percent of the indole disappears in 1 hour. If, to a duplicate tube, one adds 4 ml of Salkowski reagent, a color appears which is similar to but not identical with that given by indoleacetic acid and which is different from the color produced by indole.

For chromatographic investigation of the product, 0.4 ml of 0.005*M* indole was mixed with 1.6 ml of 0.2*M* sodium glyoxylate and incubated 2 hours at 30° C. Samples of this reaction mixture were applied to Whatman 3-MM paper, and the solvent (isopropanol, ammonia, and water, 80/5/15) was allowed to ascend 30 cm beyond the applied spots. The paper was then air-dried and sprayed with Ehrlich's aldehyde reagent. The chromatograms showed a brilliant rose-colored spot which had an R_F of 0.37 (the R_F value for indoleacetic acid under these conditions is 0.47; for indole, 0.96).

The product of the indole plus glyoxylate reaction was confirmed as indole-3-glycolic acid by cochromatography with authentic indole-3-glycolic acid that was synthesized by a new independent method, and also by a comparison of the R_F values of these two materials in various solvent systems. Indole-3-glyoxylic acid was first prepared by the method of Giua (*7*), who had erroneously designated the product as indole-2-glyoxylic acid. The correct nature of the product was established by Kharasch *et al.* (*8*), and later confirmed (*9*). The indole-3-glyoxylic acid was reduced by hydrogenation of the sodium salt over palladium, or more slowly over 5-percent palladium on charcoal, and by use of sodium amalgam. Sodium indole-3-glycolate is stable, easily purified, and obtainable in good yields, but the free acid decomposes rapidly to colored products in air (*10*) and has not been isolated in pure form.

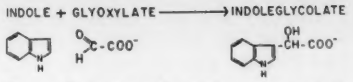


Fig. 1. Reaction of indole and glyoxylate.

The sodium indole-3-glycolate, recrystallized from methanol-ether, is a white solid with a decomposition point of 360°C. Analytic data, obtained from the Weiler and Strauss Microanalytical Laboratory, Oxford, England, are as follows. Formula, $C_{10}H_8O_3N$ Na (213.17). Calculated: C 56.33; H, 3.78; N, 6.57; Na, 10.79. Found: C, 55.68; H, 4.10; N, 6.50; Na, 10.73.

Synthetic sodium indole-3-glycolic acid, as well as the reaction product, has an R_F of 0.16 in benzene-propionic acid-water (100/70/5), 0.76 in 20-percent (wt./vol.) aqueous potassium chloride, 0.82 in *n*-butanol-acetic acid-water (4/1/1), and 0.01 in *n*-butanol-pyridine-dioxane-water (14/4/1/1). A brilliant rose-colored spot was obtained with Ehrlich's aldehyde reagent.

Pure sodium indole-3-glycolic acid, as well as mixtures of indole and glyoxylate, show distinct activity in auxin bioassays, causing extension growth of subapical etiolated pea epicotyl sections, root initiation on excised etiolated pea epicotyl sections, and inhibition of axillary buds (Table 1). It may be noted from Table

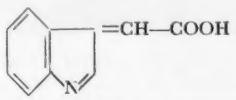
Table 1. Activity of indole-3-glycolic acid in auxin bioassays. When no values are given, no measurements were made.

Substance	Concentration	Extension growth* (mm of growth per section ± standard error)	Root initiation† (average number of roots per section)	Lateral bud development‡ (relative growth by visual estimate)
Control		3.08 ± .19	3.4	++++
Indoleacetic acid	$1 \times 10^{-6}M$	7.32 ± .32		
Indoleacetic acid	$1 \times 10^{-5}M$	5.82 ± .29		
Indoleacetic acid	$1 \times 10^{-4}M$	5.31 ± .22	7.4	++
Glyoxylate	$4 \times 10^{-3}M$	2.96 ± .18		
Indole	$4 \times 10^{-4}M$	3.79 ± .19		
Indole-3-glycolic acid	$1 \times 10^{-6}M$	3.54 ± .21		
Indole-3-glycolic acid	$1 \times 10^{-5}M$	3.65 ± .22		
Indole-3-glycolic acid	$4 \times 10^{-5}M$	4.81 ± .11		
Indole-3-glycolic acid	$1 \times 10^{-4}M$	5.04 ± .36	6.6	+++
Indole-3-glycolic acid	$4 \times 10^{-4}M$	6.73 ± .21		
Indole-3-glycolic acid	$5 \times 10^{-4}M$		14.3	+
Indole-3-glycolic acid and glyoxylate	$1 \times 10^{-4}M$, $4 \times 10^{-3}M$	5.39 ± .19		
Indole-3-glycolic acid and indole	$1 \times 10^{-4}M$, $4 \times 10^{-4}M$	8.00 ± .23		
Reaction mixture§	$4 \times 10^{-5}M$	3.50 ± .20		
	$4 \times 10^{-4}M$	7.65 ± .24		

* Eight-millimeter subapical sections of 7-day etiolated pea epicotyls floated in 5 ml test solution containing 1 percent sucrose and 0.01*M* phosphate at *p*H 6.1, 13 sections per flask, 20 hours' incubation in the dark.
† Ten-centimeter sections of 8-day etiolated pea epicotyls including second node, incubated 24 hours with basal ends in 2 ml of test solution containing 0.005*M* phosphate at *p*H 6.1, and then 7 days in frequently renewed 2-percent sucrose, all in the dark; 11 sections per flask.
‡ Same procedure as that for root initiation, but apical end in solution for the first 24 hours.
§ The reaction mixture was prepared by mixing 1.6 ml of $5 \times 10^{-3}M$ indole with 0.4 ml of 0.2*M* sodium glyoxylate and incubating for 1 hour at 30°C. Under these conditions, not all the indole disappeared. The molarity given represents that of the indole added.

1 that indole and indole-3-glycolic acid show marked synergism in promoting extension growth, and that much more indole-3-glycolic acid than indoleacetic acid is required to give maximal extension growth.

In view of the natural occurrence of indole (*11*) and glyoxylate (*12*) in various organisms, including higher plants, the possibility should be further examined that the coupling reaction and the product here described are of importance in the auxin economy of the plant. Indole-3-glycolic acid could function as an auxin per se, or could serve as a precursor of indoleacetic acid, either via direct reduction of the a-hydroxyl group, or, alternatively, via transannular dehydration to 3-carboxymethyleneindolenine,



followed by reduction.

The natural occurrence of indole-3-glycolic acid in various plant sources has been claimed (*13*), but the R_F values listed do not agree with our data. The occurrence of indole-3-glycolic acid as a breakdown product during paper chromatography of indolepyruvate has also been reported (*14*), the product in this case having an R_F close to that reported here (*15*).

J. B. GREENBERG
A. W. GALSTON
Josiah Willard Gibbs Research Laboratories, Department of Botany, Yale University, New Haven, Connecticut

K. N. F. SHAW
M. D. ARMSTRONG
Laboratory for the Study of Hereditary and Metabolic Disorders, University of Utah College of Medicine, Salt Lake City

References and Notes

1. S. A. Gordon, *Ann. Rev. Plant Physiol.* 5, 341 (1954).
2. S. G. Wildman, M. G. Ferri, J. Bonner, *Arch. Biochem.* 13, 131 (1947).
3. E. L. Tatum and D. M. Bonner, *Proc. Natl. Acad. Sci. U.S.* 30, 30 (1944); C. Yanofsky, in *A Symposium on Amino Acid Metabolism*, W. D. McElroy and B. Glass, Eds. (Johns Hopkins Press, Baltimore, Md., 1955); J. B Greenberg and A. W. Galston, *Plant Physiol.* 31, xxvi (1956).
4. C. Yanofsky, *J. Biol. Chem.* 223, 171 (1956).
5. The sodium glyoxylate used in these experiments was kindly furnished by I. Zelitch of the Connecticut Agricultural Experiment Station. Glyoxylate may be prepared by the methods of D. E. Metzler, J. Olivard, and E. E. Snell [*J. Am. Chem. Soc.* 76, 644 (1954)] and of N. S. Radin [*Biochem. Preparations* 4, 60 (1955)].
6. C. Yanofsky, in *Methods in Enzymology II*, S. P. Colowick and N. O. Kaplan, Eds. (Academic Press, New York, 1955).
7. M. Giua, *Gazz. chim. ital.* 54, 593 (1924).
8. M. S. Kharasch, S. S. Kane, H. C. Brown, *J. Am. Chem. Soc.* 62, 2243 (1940).
9. M. E. Speeter and W. C. Anthony, *ibid.* 76, 6208 (1954).
10. J. W. Baker, *J. Chem. Soc.* 1940, 458 (1940).
11. G. Klein, Ed., *Handbuch der Pflanzenanalyse III/1 Spezielle Analyse II* (Springer, Vienna, 1932), pp. 665–6.
12. G. H. N. Towers and D. C. Mortimer, *Can. J. Biochem. and Physiol.* 34, 511 (1956).
13. A. Fischer, *Planta* 43, 288 (1954).
14. J. A. Bentley *et al.*, *Biochem J.* (*London*) 64, 44 (1956).
15. This research was supported in part by research grants from the National Institutes of Health, U.S. Public Health Service and the American Cancer Society.

13 February 1957

Electrophoresis of Plasma Proteins in the Parakeet

Previous studies on electrophoresis of avian plasma or serum proteins have been limited to the goose, hen, turkey, pullet, and cockerel (*1*). The present investigation (*2*) of the plasma electrophoretic pattern of the shell parakeet (*Melopsittacus undulatus*) was undertaken during a study of the effects of spontaneous (*3*) or transplanted (*4*) pituitary tumors on these birds.

The parakeets were exsanguinated by cardiac puncture. After separation of the plasma, 10 mm³ was applied to Whatman 3-mm filter paper on a conventional vertical principle electrophoretic cell of our own design utilizing Veronal buffer at *p*H 8.6, μ 0.05 with 5 percent glycerine. Migration was permitted for 4 hours, using 150 to 170 v delivering 15 to 20 ma for paper measuring 10 by 14 cm. Pooled human serum was used for mobility reference. After heat fixation the papers were stained with bromphenol blue for protein and Sudan black B for lipoprotein. Scanning of the papers was accomplished with an automatic photoelectric cell recording apparatus with simultaneous area integration (Spinco Analytrol).

As can be seen in Fig. 1, there is considerable variation in the quantity of these four fractions in the normal parakeets that have been studied. By the methods used, no essential differences were discernible between the electrophoretic patterns of serum and plasma from the same birds. Although it appears probable that the protein composition of parakeet serum should differ from that of the plasma, the method of filter-paper electrophoresis is not adequate to demonstrate such a difference. Plasma was used in all studies because of the ease of handling the small samples of whole blood available. Each of the four components has an affinity for Sudan black B, although differing in intensity. Component 1 stains darkly with lipid stain, component 2 is barely perceptible, and components 3 and 4 stain as a single component of lesser intensity than component 1. Lipid staining also is seen at the point of application of the plasma, showing a nonmigrating component, probably chylomicrons.

Four protein components were recognized in normal parakeet plasma; these have been named components 1, 2, 3, and 4 in order of decreasing mobility (Fig. 2). Component 1 migrates faster than human albumin and represents 32 percent (range, 17 to 63 percent) of the total protein. Component 2 travels at a rate intermediate between human α_1- and α_2-globulin and occupies 16.5 percent (range, 6 to 28 percent) of the total area scanned. Component 3 is in juxtaposition to component 4 in a migratory area of human β-globulin, the former representing 22.5 percent (range, 8 to 45 percent) and the latter 29 percent (range, 17 to 48 percent) of the total plasma protein.

These normal patterns are strikingly altered in the plasma of parakeets bearing either primary or transplanted pituitary tumors; the quantity of protein observed to migrate as component 2 is greatly increased, representing 59 percent (range, 45 to 65 percent) of the total protein. To date, this has been ob-

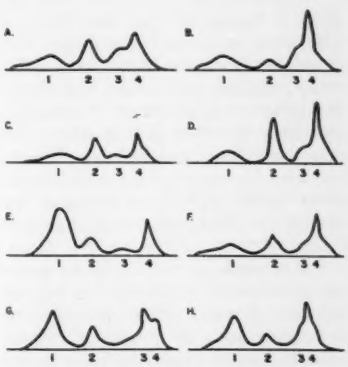


Fig. 1. Plasma electrophoretic pattern of eight normal parakeets, showing wide variations in the quantity of the four protein components.

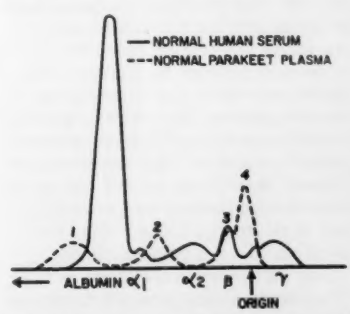


Fig. 2. Zone electrophoretic pattern of parakeet plasma compared for electrophoretic mobility with normal human serum.

served in all parakeets that bear these tumors and has not been found in parakeets with other primary and transplanted tumors such as fibrosarcoma and methylcholanthrene-induced carcinoma nor has the increased protein associated with an elevated serum calcium such as has been described in estrogen-treated roosters been found (*5*).

ROBERT L. WALL
HANS G. SCHLUMBERGER
Departments of Medicine and *Pathology, Ohio State University College of Medicine, Columbus*

References and Notes

1. R. H. Common, W. P. McKinley, W. A. Maw, *Science* 118, 86 (1953).
2. This work was aided by grants from the National Cancer Institute, U.S. Public Health Service, and the American Cancer Society.
3. H. G. Schlumberger, *Cancer Research* 14, 237 (1954).
4. ———, *ibid.* 16, 149 (1956).
5. O. A. Schjeide and M. R. Urist, *Science* 124, 1242 (1956).

18 February 1957

Citrus Fruit Grafting

The grafting of a citrus fruit from one plant to another has not been reported previously, as far as I am aware. This technique should be useful in studying many problems, particularly when fruits are desired on small plants. A technique previously described (*1*) in which cuttings with fruits attached were rooted and used for experimental purposes has many useful applications but does not provide the flexibility offered by grafted plants.

For example, by employing the grafting technique, it is possible to study the influence of leaves on fruit development and composition by producing various combinations of leaves and fruits. Nitsch (*2*) suggested that organic acids are probably produced in the leaves and translocated to the fruits. On the other hand, Sinclair and Eny (*3*) and Sekhara Varma and Ramakrishnan (*4*) suggested that the large amounts of organic acids in lemon pulp are not translocated from the leaves but formed from the sugars in the juice vesicles. By grafting a sweet lemon fruit on a sour lemon plant, it was thought that information about the accumulation of organic acids in lemons might be obtained. The results of preliminary experiments of this type using sweet and sour lemons, both of which belong to the species *Citrus limon* (Linn.) Burmann (*5*), are presented here.

The Faris sweet lemon, used in these experiments, is distinguishable from sour forms in the bland, insipid taste of the juice, which has less than 1 percent acid in tree-ripened fruit in contrast with 4½ to 6 percent acid in the Ross Eureka, a commercial variety. On 25 May 1956, eight immature Faris sweet lemons were successfully grafted on Ross Eureka lemon plants growing in the greenhouse in number 10 cans. The fruits were picked and juiced when mature, between 20 July and 6 December. For comparison, Ross Eureka lemons that had been similarly grafted on 4 May were used. Vegetative branches appearing on the scions about 3 weeks after grafting (Fig. 1) were removed from half of the plants.

Analyses were made of the juice from the fruits for percentage titratable acid, *p*H, total soluble solids (refractometric reading), and sugars. The sweet lemon fruits grafted on sour lemon plants generally remained low in acid content. However, on those plants which had leaves from the sweet lemon scion in addition to leaves on the sour lemon stock, the acid content of the fruit (1.31 percent) was somewhat greater than it was on plants from which scion sprouts had been removed (0.32 percent). Whether this difference in acid content was in response to the combination of foliage, improved graft union, or some other cause remains to be determined.

Concurrently, another experiment was started in which Ross Eureka lemon plants were grafted with either Faris sweet lemon scions or Ross Eureka scions. When the vegetative shoots were about 2 to 4 feet long, sweet or sour lemon fruits were grafted on the tops in four combinations. All scion sprouts were removed as they appeared so that a single source of foliage existed on each plant. The fruits were grafted on 3 August, 1956, and on 10 September when the first fruits became yellow, one fruit of each of the four combinations was picked. At approximately monthly intervals, the remaining fruits matured and were picked, so that on 6 December the last set of four fruits was removed from the plants.

Results of analyses of the fruits showed that all the sweet lemon fruits remained low in acid concentration whether they were nourished by leaves of sour (0.52 percent acid) or sweet (0.44 percent acid) lemon plants. Also, the sour lemons remained high in acid concentration whether they were nourished by leaves of sweet (5.18 percent acid) or sour (5.18 percent acid) lemon plants. Aside from the characteristic of a lower acid concentration, the sweet lemons had a much higher reducing sugar concentration (5.17 percent) than did the sour lemons (1.45 percent).

The total soluble solids in the two types of fruits were about the same. After the acid and sugars had been subtracted from the total soluble solids only one or two percent soluble solids remained undetermined. The difference in undetermined soluble solids between

Fig. 1. Lemon fruit grafted 4 May 1956, photographed 29 May. Sprouts on the scion indicate successful graft union. Fruit was 51.4 mm in diameter when grafted and 65.2 mm when mature on 11 December; the calculated increase in volume is 63 percent.

sweet and sour fruits was only a fraction of the difference in acid concentration, thus indicating that acid was lacking in the sweet fruit rather than that it was present in a nontitratable salt form.

The failure of a sweet lemon, such as the Faris, to accumulate high concentrations of organic acids, when grafted on a sour lemon plant, such as the Ross Eureka, indicates that the high concentration of organic acids in a lemon is more complex than that which would result merely from the translocation of acid from leaves to fruit and accumulation in the latter site.

Further studies are required to determine to what extent leaves can modify fruit composition. By using the technique of grafting fruits, it will be possible to extend the study and to employ orange, grapefruit, and other foliage to produce lemons and other citrus fruits.

LOUIS C. ERICKSON
Department of Plant Biochemistry, University of California Citrus Experiment Station, Riverside

References and Notes

1. L. C. Erickson and P. DeBach, *Science* 117, 102 (1953); P. DeBach and L. C. Erickson, *J. Econ. Entomol.* 45, 1097 (1953).
2. J. P. Nitsch, *Ann. Rev. Plant Physiol.* 4, 199 (1953).
3. W. B. Sinclair and D. M. Eny, *Botan. Gaz.* 108, 398 (1947).
4. T. N. Sekhara Varma and C. V. Ramakrishnan, *Nature* 178, 1358 (1956).
5. H. J. Webber and L. D. Batchelor, *The Citrus Industry* (Univ. of California Press, Berkeley, 1943), vol. 1, p. 589.

25 February 1957

Book Reviews

The Reactive Intermediates of Organic Chemistry. John E. Leffler. Interscience, New York, 1956. 275 pp. Illus. $6.

During the last year or two, a number of books dealing with reaction mechanisms and physical organic chemistry have appeared. A few have been good, but more have been unsatisfactory for one reason or another. John Leffler has pulled off a major feat by writing not only a fine book but also one that differs notably in approach from all previous ones, and one that is written in such an engaging style that most chemists who are at all interested in these fields will wish to read it.

As the title, *The Reactive Intermediates of Organic Chemistry,* implies, radicals, carbonium ions, and carbanions are used as a framework for discussing reaction mechanisms and a variety of other topics in organic chemistry. The sections on each of these intermediates are introduced by a discussion of the physical and other evidence for the existence of these species. A brief discussion of the effect of structural variations on rates and equilibriums of formation is followed by well-thought-out sections on reactions which go through these intermediates. Although the classical experiments are adequately described, Leffler has managed to find less familiar examples to demonstrate many of his points, so that even someone who is familiar with the field is not left with the feeling of having heard it all before. Although the approach is not at all a kinetic one, qualitative discussions of such topics as solvent effects on rates, ion pairs, and neighboring group rate enhancements are included. But the absence of a discussion of the displacement reaction is to be regretted.

Undoubtedly, the most valuable parts of the book are the chapters that are devoted to free radicals—their production and reactions. Usually, free radical reactions are relegated to a small section buried somewhere near the back of chemistry textbooks. Finding the first four chapters of this book devoted to this topic is likely to be a wholesome shock and is perhaps a landmark along the road to respectability for radical chemistry. In these chapters, as elsewhere, Leffler resists the temptation to oversimplify. However, his qualifications and asides are usually unobtrusive enough not to confuse the novice, yet strong enough to give pause to more advanced readers. Advanced students, especially, will profit from a careful reading of the text, since Leffler presents the material in a very scholarly manner, with full awareness of the many pitfalls for the unwary and with no personal theories to push. On the other hand, the small size of the book makes long discussions impossible, and there are few wasted sentences. Persons who meet this field for the first time in the pages of this book may well find the going difficult. The returns, in terms of a mature understanding of the subject matter, should be correspondingly great.

CHARLES H. DEPUY
Iowa State College

Elasticity, Fracture and Flow. J. C. Jaeger. Methuen, London; Wiley, New York, 1956. 152 pp. Illus.

Elasticity, Fracture and Flow, a beautifully written little volume, provides a concise perspective of the theories of deformation and failure of materials under the influence of external loading. It is especially characterized by the care with which assumptions and definitions are stated and by the emphasis that is placed on the limitations inherent in each argument presented. There has been a tendency in a great deal of the literature on this subject to rush into formal manipulation without a critical examination of the physical applicability of the hypotheses that underlie the formal approach. J. C. Jaeger's exposition is the antithesis of this.

In a sense, the method of attack is similar to that in comparative physiology or comparative anatomy, where a deeper understanding of the functions and structure of organs is acquired by comparing them in different species. Instead of pursuing the theory of perfectly plastic materials or that of viscous fluids or that of brittle substances as separate disciplines, Jaeger makes an attempt here to show how the properties of substances differ from one another on the basis of the various theories. Thus, this book goes far toward supplying a much needed "connective tissue" for the topic.

The text is divided into three chapters and subdivided into 41 sections. The first chapter provides a thorough and facile introduction to the specification of stress and strain in deformation. Of particular interest are the sections on finite strain.

The second chapter, on the behavior of actual materials, includes discussion of the stress-strain relationships for elastic isotropic solids, anisotropic substances, natural strain, the Griffith theory of brittle strength, Mohr's theory of fracture, the maximum shear stress theory (Tresca), and the maximum distortional strain energy theory (Maxwell-Huber-Hencky-von Mises). There is also a short section on rheological models, including Hookean, Newtonian, Kelvin-Voigt, Maxwell, general linear, and Bingham substances.

The last chapter opens with a discussion of some simple problems that illustrate the differences between the various substances mentioned in the preceding paragraph. The elastodynamic stress equations are derived, and properties of dilatational (P), shear (S), and Rayleigh waves are presented. Some problems of elastostatics are also given. These include a brief description of the stress function (Airy) and of plane stress and plane strain. Finally, some special problems in viscosity and plasticity are treated.

In my opinion, in view of the range of topics covered, the book is outstanding. Very little a priori knowledge of the subject on the part of the reader is assumed by the author. Extreme clarity, unusual consideration for the reader in pointing out limitations, and a combination of comprehensiveness and conciseness all contribute to make this book a desirable acquisition for materials specialists, engineering students, and interested scientists in other fields.

A. KYRALA
Lessells and Associates, Boston

Human Generation, Conclusions of Burdach, Döllinger and von Baer. Arthur W. Meyer. Stanford University Press, Stanford, Calif.; Geoffrey Cumberlege, Oxford University Press, London, 1956. 143 pp. Illus. $3.50.

In this little book, which will be of real interest to all those who concern themselves with the history of embryology, A. W. Meyer has translated, from the Latin, some of the less accessible monographs of the great early 19th-century figures in this field and has

added chapters of annotation and explanation. The first two chapters are concerned with K. F. Burdach (1776–1847) and give a translation of his paper on the first changes in the formation of the human fetus. The next two chapters deal with the life and work of J. J. I. von Döllinger (1770–1841) and add a translation of his history of human reproduction. The last seven chapters are concerned with K. E. von Baer (1792–1876), no doubt the greatest of the three, and give a translation of his commentary on the eggs of mammals and man. There is a biographical synopsis, a study of the influence of the *Naturphilosophie* on von Baer, and a discussion of his education, personality, period of exhaustion, and unclaimed and uncredited discoveries.

The whole book is the product of very respectable scholarship and must be regarded as a permanent and extremely welcome contribution to the literature of this important branch of the history of biology. Certainly, no greater formative period in this science existed than that at the beginning of the 19th century—the time of the discovery of the mammalian ova—and everyone concerned with this field will be eager to possess this volume.

I feel duty bound to note, with regret, that the learned author did not select for translation Burdach's monograph, *De Commutatione Substantiarum Proteinacearum in Adipem*. In this writing, if my memory is correct, Burdach claimed to have found an actual increase in the fat content of the developing egg of mollusks (pond-snails). This observation seems extremely strange in the light of all that is known about the use of reserve substances during embryonic development, but modern knowledge indicates that the biochemistry of the developing egg of mollusks *is* very strange (as, for example, in its stores of galactogen), and it would be curious if modern research were to confirm such experiments, carried out more than a century ago.

JOSEPH NEEDHAM
Caius College, Cambridge University

Fleas, Flukes and Cuckoos. A study of bird parasites. Miriam Rothschild and Theresa Clay. Macmillan, New York, ed. 3, 1957. xiv + 305 pp. $5.

Fleas, Flukes and Cuckoos is the third editon of a work first published in 1952 [see *Sci. Monthly* **75**, 252 (1952)]. The mere fact that such a book has gone through three editions in 5 years indicates that it has met, and has successfully answered, a real need. The text of the volume is essentially the same as in the earlier printings, but on pages xiii and xiv are listed the additional data and the changes in qualifications of statements taken from the first edition.

The two authors are among the most prominent specialists on avian ectoparasites and are highly competent to handle the various topics that are discussed. The book is divided into three main parts. The first of these includes a general discussion of parasitism, commensalism, symbiosis, the mutual effects and interrelations of parasites and hosts, and the origins of parasitism. The second part deals with fleas and feather lice, while the third part has a much more heterogeneous content: it deals with endoparasites, such as protozoans and worms, and also with ectoparasites such as flies and mites. The latter are grouped here probably because their larvae are subcutaneous parasites of the avian host. From these, the authors go on to include food predator-parasites such as the skuas, and brood parasites, exemplified by the European cuckoo, but the treatment afforded these topics is much less detailed than is the discussion of body parasites.

HERBERT FRIEDMANN
Smithsonian Institution

Medical Sciences. ser. VII, *Progress in Nuclear Energy*. J. C. Bugher, J. Coursaget, and J. F. Loutit, Eds. McGraw-Hill, New York; Pergamon, London, 1956. 165 pp. $6.

This book is a product from the pens of ten different authors, each distinguished in his own right and carefully selected from among the participants in the 1955 International Conference for the Peaceful Uses of Atomic Energy, held in Geneva. Perhaps only a few readers will be thoroughly familiar with all the medical and physics terminology, but, for the most part, there is sufficient supporting discussion to enable the reader who has only a general scientific knowledge to glean an immense amount of useful information. For those busy persons in medical research, radiology, medical physics, and health physics who do not have time to read all the voluminous medical and health physics reports given at the 1955 conference, this book provides a welcome opportunity to make this review in a few evenings of thoughtful reading. The long lists of supplementary references should be helpful, as a quick source of information and a valuable starting point for one writing papers in this field. In some cases, mention is made of a new application of radionuclides to medical research, or to medical diagnosis, with little or no indication of its success or probable ultimate application to medical practice. This limited and tantalizing introduction to a variety of subjects can be expected in such a cursory review of a frontier subject, and, as a result, readers interested only in having a look at descriptive information will be discouraged, while those who like to tease their imaginations will have much to reflect on, and a few may be encouraged to read some of the references.

The fact that this book has two forewords may be, at first, a surprise to the reader, but later he realizes that these two forewords are not written for one but for about ten different books, all condensed and bound into this single volume. Here we have, summarized, the most interesting and important disclosures in the fields of medicine, radiobiology, and health physics, as presented by approximately 100 speakers at the 1955 conference.

Those readers who have been apprehensive about predictions of miracles that will be performed in the therapeutic use of radioactive material will be interested in the statement of Stone that, with the single exception of the method of using radioiodine, no radical departures from previous techniques have been set forth, and that the field of greatest usefulness of radioisotopes to medicine is that of applying tracer techniques to obtain more insight into the workings of the body. Ernest Rock Carling points out the great advances made by industry in adapting the radioisotope tool to research, and, at the same time, he calls our attention to the many associated problems of radiological protection.

The first chapter, titled "Radioactive isotopes in medical diagnosis," by E. H. Belcher and M. V. Mayneord, is very thought-provoking and reviews an immense variety of medical diagnostic studies, such as blood volume, red cell life, tumor detection, and thyroid function.

Chapter 2, by J. F. Ross, deals with the "Diagnosis and investigation of disease with radioactive isotopes." Ross points out the unique contributions of radioisotope tracer techniques in clarifying the dynamic aspects of metabolic and physiologic processes, through determination of the actual rates at which vital functions proceed, the chemical pathways involved, the localization of sites in the body where they occur, and so forth.

Chapters 3 and 4, by J. S. Mitchell, deal with "Nuclear radiations for radiotherapy with external sources and radioactive materials for internal therapy." The reader learns that, for external radiotherapy, Co^{60} is somewhat superior to Ra, and that Ir^{192}, Ce^{144}, Eu^{152}, and Cs^{137} offer certain advantages as external sources for radiotherapy. The P^{32} treatment of patients with lymphatic leukemia and lymphoblastoma of giant follicles yields very favorable results. The mean life of patients with chronic myelogenous leukemia is about the same

when treated with P^{32} but probably not greater than when treated by other methods. In the case of patients with polycythemia vera who are treated with P^{32}, the mean life is approximately double that of similar patients treated by conventional methods. While pointing out the great promise in the therapeutic use of radionuclides, especially in the selected use of P^{32} and I^{131}, Mitchell calls attention to many difficult associated problems. He cautions against overirradiation of the marrow and warns of the risks of carcinogenesis.

Chapter 5, by W. Binks, deals with "Principles and standards of radiation safety." Many common terms, such as *absorbed dose, rad, rem,* and *R.B.E.,* are defined. Whereas most of the radiation standards in the U.S.S.R. are similar to those in other countries, there are some interesting differences. Administrative and legal problems associated with the use of radioisotopes are discussed.

The late A. J. Cipriani wrote the sixth chapter, dealing with "Health and safety activities in reactor and chemical processing plants."

The final chapter, by G. Failla, is titled, "Dosimetry of ionizing radiation," and is an extended discussion of the Bragg-Gray principle and of the two associated parameters—stopping power and energy—required to produce an ion pair.

KARL Z. MORGAN
Oak Ridge National Laboratory

New Books

Black Bourgeoisie. The rise of a new middle class in the United States. E. Franklin Frazier. Free Press, Glencoe, Ill., 1957. 264 pp. $4.

Modern Science and the Nature of Life. William S. Beck. Harcourt, Brace, New York, 1957. 319 pp. $5.75.

Instrumental Analysis. Paul Delahay. Macmillan, New York, 1957. 395 pp. $7.90.

Annuaire des Organisations Internationales. 1956–57. L'Union des Associations Internationales, Brussels, ed. 6, 1957. 1266 pp. $10.

Nuclear Reactors for Research. vol. 3 in *The Geneva Series on the Peaceful Uses of Atomic Energy.* Clifford K. Beck, Ed. Van Nostrand, Princeton, N.J., 1957. 279 pp. $8.50.

Man against Germs. A. L. Baron. Dutton, New York, 1957. 320 pp. $4.50.

Mathematics, Magic and Mystery, Martin Gardner. Dover, New York, 1956. 188 pp. $1.

The Chemical History of a Candle. Michael Faraday. Reprinted with foreword by E. N. da C. Andrade; biographical introduction by Sir J. Arthur Thomson. Crowell, New York, 1957. 190 pp. $2.75.

Notions de Cytologie et Histologie. M. Chèvremont. Desoer, Liége, 1956. 998 pp.

Elementary Practical Organic Chemistry. pt. I, *Small Scale Preparations.* vol. 1 of *Elementary Practical Organic Chemistry.* Arthur I. Vogel. Longmans, Green, New York, 1957. 376 pp. $4.50.

Frontiers of Knowledge in the Study of Man. Lynn White, Jr., Ed. Harper, New York, 1956. 342 pp. $4.50.

Jets, Wakes, and Cavities. vol. 2 of *Applied Mathematics and Mechanics.* Garrett Birkhoff and E. H. Zarantonello. Academic Press, New York, 1957. 365 pp. $10.

Tables of the Non-Central t-Distribution. Density function, cumulative distribution function, and percentage points. *Stanford Studies in Mathematics and Statistics,* 1. George J. Resnikoff and Gerald J. Lieberman. Stanford University Press, Calif., 1957. 389 pp. $12.50.

Building an Engineering Career. Clement C. Williams and Erich A. Farber. McGraw-Hill, New York, ed. 3, 1957. 309 pp. $4.75.

The American Oasis. The land and its uses. Edward Higbee. Knopf, New York, 1957. 272 pp. $5.

Muscle Relaxants in Anesthesiology. A monograph in the Bannerstone Division of American Lectures in Anesthesiology. Francis F. Foldes. Thomas, Springfield, Ill.; Blackwell, Oxford, England; Ryerson, Toronto; 1957. 232 pp. $5.50.

The Challenge of Soviet Education. George S. Counts. McGraw-Hill, New York, 1957. 343 pp. $6.

Thermodynamics and Statistical Mechanics. A. H. Wilson. Cambridge University Press, New York, 1957. 510 pp. Illus. $9.50.

Life, Language, Law. Essays in honor of Arthur F. Bentley. Richard W. Taylor, Ed. Antioch Press, Yellow Springs, Ohio, 1957. 235 pp. $4.50.

Treatise on Marine Ecology and Paleoecology. vol. 2, *Paleoecology.* Memoir 67. Harry S. Ladd, Ed. Geological Society of America, New York, 1957. 1087 pp. $10.

The Conquest of the Antarctic. Norman Kemp. Philosophical Library, New York, 1957. 152 pp. $4.75.

Comfort for Survival. In nature and man. Angus M. Woodbury. Vantage, New York, ed. 1, 1957. 110 pp. $3.

Living Chemistry. Maurice R. Ahrens, Norris F. Bush, Ray K. Easley. Ginn, Boston, rev..ed. 2, 1957. 638 pp. $5.28.

The Theory of Social Structure. S. F. Wadel. Free Press, Glencoe, Ill., 1957. 175 pp.

Plant Ecology. William Leach. Methuen's Monographs on Biological Subjects. Michael Abercrombie, Ed. Methuen, London; Wiley, New York, ed. 4, 1957. 113 pp. $2.

The Idealist Tradition. From Berkeley to Blanshard. vol. 1 of *The Library of Philosophical Movements.* Paul Edwards, Ed. Free Press, Glencoe, Ill., 1957. 376 pp. $5.50.

Year Book 1955–1956. With administrative reports through 14 Dec. 1956. Carnegie Institution of Washington, 1956. 383 pp. Cloth, $1.50; paper, $1.

A Handbook of Hard Metals. W. Dawihl. Abridged English translation of *Handbuch der Hartmetalle.* Philosophical Library, New York, 1956. 170 pp. $10.

Hémostase Spontanée, Plaquettes Sanguines et Parois Vasculaires. Actes du 1er symposium de la Fondation V. Baldacci. J. Roskam, Ed. Istituto di Ricerche V. Baldacci, Pisa, Italy, 1956. 190 pp.

Walt Disney: Secrets of Life. A true-life adventure. Rutherford Platt and the staff of the Walt Disney Studio. Based on the film narration by James Algar. Simon and Schuster, New York, 1957. 124 pp. $2.95.

The Wonder of Snow. Corydon Bell. Hill and Wang, New York, 1957. 285 pp. $5.

Introduction to Psychology. Ernest R. Hilgard. Harcourt, Brace, New York, ed. 2, 1957. 668 pp.

Beekmantown Group (Lower Ordovician) of Maryland. William J. Sando. Memoir 68. Geological Society of America, New York, 1957. 161 pp.

Plant Virus Serology. R. E. F. Matthews. Cambridge University Press, New York, 1957. 139 pp. $5.

The Americana Annual: 1957. An encyclopedia of the events of 1956. Lavinia P. Dudley and John J. Smith, Eds. Americana Corp., New York, 1957 (order from Americana Corp., 333 N. Michigan Ave., Chicago). 936 pp. $12.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, *but to the publisher or agency sponsoring the publication.)*

Laboratory Manual of Microbiology. H. Magdalene Steward. Mosby, St. Louis, ed. 2, 1957. 103 pp. $2.25.

Higher Education and the Society It Serves. Statements presented at the annual meeting of the American Council on Education, 11–12 October 1956, Chicago. Raymond F. Howes, Ed. American Council on Education, Washington, 1957. 103 pp. $1.

Two New Species of Birds from Angola. Fieldiana: Zoology, vol. 39, No. 5. Austin L. Rand, 5 pp. $0.15. *The Bayou Goula Site, Iberville Parish, Louisiana.* Fieldiana: Anthropology, vol. 47, No. 2. George I. Quimby. 170 pp. $1.75. *The Present Status of the Volcanoes of Central America.* Fieldiana: Geology, vol. 10, No. 28. Sharat Kumar Roy. 5 pp. $0.15. *Early Cretaceous Mammals and the Evolution of Mammalian Molar Teeth.* Fieldiana: Geology, vol. 13, No. 1. Bryan Patterson. 105 pp. $2.25. Chicago Natural History Museum, Chicago, 1957.

Emmetropia and Its Aberrations. A study in the correlation of the optical components of the eye. Special Report Series No. 293. Arnold Sorsby, B. Benjamin, J. B. Davey, M. Sheridan, J. M. Tanner. Medical Research Council, London, 1957 (order from Her Majesty's Stationery Office, London). 69 pp. 7s. 6d.

Anatomical Atlas. Maud Jepson. Rinehart, New York, 1957. 24 pp. $0.95.

The Measurement of Body Radioactivity. Papers read at a conference held at Leeds on 16–17 April 1956. Supplement No. 7, *British Journal of Radiology.* C. B. Allsopp, Ed. British Institute of Radiology, London, 1957. 130 pp. 25s.

Meetings and Societies

Role of Gravitation in Physics

Some 45 physicists from England, Denmark, France, Germany, Japan, Sweden, Turkey, and the United States met at the University of North Carolina, Chapel Hill, 18–23 Jan., for a week of working sessions to discuss the role of gravitation in physics. The conference was the first formal activity of the Institute of Field Physics, Inc., whose North Carolina project was established within the department of physics of the University of North Carolina in 1956. The conference was sponsored by the International Union of Pure and Applied Physics, the National Science Foundation, the Wright Air Development Center of the U.S. Air Force, the Office of Ordnance Research of the U.S. Army, and the Institute of Natural Science of the University of North Carolina.

The title of the conference emphasizes the fact that gravitation, although one of the earliest theories in physics, has so far remained isolated and has very few links with other branches of physics. The works of Galileo, Newton, and Einstein —of great intellectual beauty—seem, at first, to be completely self-contained. But if, as a working hypothesis, we believe in the organic whole of nature, we want to investigate the concepts which would bring gravitation intimately into our description of nature. In particular, a quantum theory of gravitation would bring together the laws of the very small and of the very large. Even if no real progress is made, in the course of such an investigation, toward linking the theory of gravitation more closely with the other physical theories, the investigation in itself would force us into a deeper understanding of both gravitation and other physical theories.

The first session of the conference was devoted to a report on experiments which substantiate the Einstein relativistic theory of gravitation. Very few such experiments are feasible with present-day techniques, and the scarcity of experimental guideposts is one of the biggest difficulties for researchers in this field. The three well-known astronomical observations were briefly mentioned only to express the wish that they could be performed with more accuracy. On the other hand, the accuracy of the Eötvös experiment (1890), which proves the equivalence of the gravitational and inertial mass (in other words, that all bodies fall at the same rate in the same gravitational field) can now be increased from 1 part in 10^8 to 1 part in 10^{11}. There are other experiments which could also delineate the validity of Einstein theory, such as the "clock experiment," which can now be performed on earth, and the measure of the (absence of) secular variation in the strength of the gravitational interaction.

The next session of the conference covered some advances which have been made recently in the mathematics of Einstein's equations. The extraordinary mathematical difficulties involved in the study of gravitation have not yet been overcome, but some tools developed by mathematicians in the study of integration of nonlinear partial differential equations and properties of their solutions, and by physicists in their studies of quantum field theories, foster a renewed interest in the subject.

The working sessions were divided, for convenience, into sessions on classical general relativity and sessions on quantized general relativity. The main problems discussed in the classical group were the following: (i) Do the equations predict the existence of gravitational waves? (ii) What are the true observables of the theory (as opposed to variables of integration chosen for mathematical convenience)? (iii) Which invariants and topological problems might lead to a grasp of the physical reality of the gravitational field?

The first question raised in the sessions on quantum field theory was, Why quantize the gravitational field? The theory of measurement in the context of gravitation can tell us whether there is a logical necessity for quantizing the gravitational field. It seems at present that there is a logical need either to quantize the gravitational field or else to introduce a new basic principle in physics. Even without settling this question, physicists are interested in tackling the technical problems of quantization of the gravitational field, partly because of their present difficulties in understanding existing quantum field theories and elementary particles and partly because it is a challenging problem in itself. One of the techniques most discussed was the use of Feynman's path integral in curved space.

Cosmologists were invited to report on some advances in their field that are of interest for the theory of gravitation and, as one conferee said, "to give us a view of applied gravitation theory."

A short report cannot give a picture of the active discussions that went on among the conferees. Most of them are working almost wholly independently of one another and are eager to engage in discussions of all the difficulties they have encountered and the results that they are beginning to obtain. This conference was the second one devoted to the subject of gravitation; the first "A jubilee of relativity theory," was held in Bern, Switzerland, in 1955. All the conferees wished to have other opportunities to meet together; specifically, it is hoped that another conference will be held in the summer of 1958.

A report on the proceedings of the conference is now in press and will be distributed as a U.S. Air Force technical report. Inquiries concerning this report should be sent to Wright Air Development Center, attention: WCRRX, Wright-Patterson Air Force Base, Ohio.

Papers related to the subjects discussed at the conference will appear in the July issue of *Reviews of Modern Physics*.

CECILE DEWITT
University of North Carolina, Chapel Hill

African Studies Association

At a recent weekend conference in New York of 35 leading scholars and specialists on African affairs, Melville J. Herskovits, director of the Northwestern University Program of African Studies, was elected president of the newly created African Studies Association. During the 2-day conference, the decision was taken to establish a formal organization to serve the needs and interests of individual scholars, university African programs, and organizations concerned with Africa.

In view of the postwar proliferation of scholarly associations, a majority of Africanists have previously displayed a reluctance to set up an African studies association until the usefulness of such a body could be clearly demonstrated. However, the continually increasing importance of Africa in world affairs, and the attraction of an ever-growing number of specialists to African research, convinced those attending the conference that a clearing house was needed for the cross-dissemination of information on Africa.

Reflecting the activities and interests of most of those attending the confer-

ence, the African Studies Association will focus attention upon the problems of sub-Saharan Africa. However, throughout Africa's long history, trade and commerce have repeatedly breached the Saharan barrier to link North and South Africa. With ties between the two regions strengthened by modern communications and with an expressed interest among the leaders of independent Africa for the creation of an African bloc, the association will welcome to its membership specialists in North African research.

The functions of this nonpolitical association will be to facilitate communication among scholars interested in Africa and to stimulate research on Africa by specialists in various scientific disciplines and the humanities.

The conference concluded its work by setting up a temporary organization and electing officers. In addition to naming Herskovits as president, Gwendolen M. Carter, Smith College political scientist, was elected to the vice presidency. The board of trustees that was empowered to draft a constitution and administer association affairs until the convening of the first annual meeting included: W. O. Brown, director, Boston University African Studies Program; John Considine, professor of contemporary world affairs at Maryknoll Seminary; L. Gray Cowan, Columbia University; Leonard Doob, Yale University; Walter Goldschmidt, anthropologist, University of California at Los Angeles; Franklin Frazier, Howard University; C. W. de Kiewiet, president, University of Rochester; and Vernon McKay, professor of African studies at the Johns Hopkins University.

AAAS Meeting Support

Additional contributions to help reduce the deficit of the AAAS meeting held in New York, 26–31 Dec. 1956, have been received from the following during the months since the report of the meeting was made [*Science* **125**, 285 (15 Feb. 1957)]: Chase Manhattan Bank; S. Sloan Colt, chairman of the board, Bankers Trust Company; Eastman Kodak Company; Erwin, Wasey and Company, Inc.; General Dynamics Corporation; Johnson and Johnson; National Cash Register Company; Owens-Illinois; Pfizer Foundation, Inc.; Phelps Dodge Corporation; Socony Mobil Oil Company, Inc.; Union Carbide Corporation; United States Steel Corporation; and Winthrop Laboratories.

College Administration

The annual Institute on College Administration for presidents, deans, and other administrative officers will be held at the University of Michigan from 15–19 July. Major themes to be covered in the program include: problems and trends in higher education; curriculum planning and administration; human relations factors in personnel administration; student personnel problems; and purposes of higher education and their implementation. Those attending the institute will have opportunity to help determine specific topics and problems to be discussed at the afternoon sessions. Special attention will be given to the use of institutional self-studies.

The director of the institute will be Algo D. Henderson, professor of higher education, and the assistant director will be James M. Davis, assistant professor of education and director of the International Center, both of the University of Michigan. Other staff will include Earl McGrath, director of the Institute for the Study of Higher Education, Teachers College, Columbia University; Frank R. Kille, dean of Carleton College; E. G. Williamson, dean of students, University of Minnesota; and administrative officers and professors of the University of Michigan. Additional information may be obtained by writing to Algo D. Henderson, 2442 U.E.S., University of Michigan, Ann Arbor, Mich.

Biological Symposium

The eighth annual Biological Symposium of the University of Michigan Summer Session will be held 9–11 July. The general subject is "Hormones and growth." The speakers will be Dietrich Bodenstein (Army Chemical Center), Roy O. Greep (Harvard University), Frederick L. Hisaw (Harvard University), and Folke K. Skogg (University of Wisconsin).

Housing may be secured by writing directly to the Michigan Union, 530 S. State St., Ann Arbor, Mich. Other inquiries may be directed to Dr. Burton L. Baker, Department of Anatomy, University of Michigan, Ann Arbor.

Mammalian Cell Culture

A 3-day series of conferences and laboratory demonstrations dealing with quantitative methods of mammalian cell culture will be presented by the department of biophysics, University of Colorado Medical Center, in Denver, Colo., 9–11 Sept. The techniques for quantitative growth on plates of single mammalian cells and isolation of clonal stocks will be demonstrated. Application of these methods to problems of mammalian cell growth, genetics, nutrition, and interaction with agents like x-radiation and viruses will be considered.

These sessions are open to responsible scientists engaged in teaching and research. Inquiries should be directed to the Office of Graduate and Postgraduate Education, University of Colorado Medical Center, Denver 20, Colo. Applications will be accepted in the order of their receipt, to the limit of the available accommodations. The conference is sponsored by the Colorado Division of the American Cancer Society.

International Conference on Pesticides

The International Conference on Pesticides that was to be held 16–18 Oct., if sufficient supporting funds became available, has been postponed. The funds subscribed totaled $14,250, which was something short of the $25,000 minimum considered necessary; therefore, plans for holding the conference in 1957 have had to be canceled. If sufficient interest continues, development of plans for a conference in 1958 will be considered.

Origin of Life

A Symposium on the Origin of Life, organized under the auspices of the International Union of Biochemistry, will be held in Moscow, U.S.S.R., 19–24 Aug., followed by a visit to Leningrad. Further details can be obtained from the secretary of the Organizing Committee, Prof. G. A. Deborin, Institute of Biochemistry, U.S.S.R. Academy of Sciences, B. Kaluzskaya 33, Moscow, B.71, U.S.S.R.

Forthcoming Events

June

10–11. Instrumentation in Medicine and Biology, symp., Ridgefield, Conn. (J. H. Heller, New England Inst. for Medical Research, Ridgefield.)

11–13. American Meteorological Soc., Monterey, Calif. (K. C. Spengler, AMS, 3 Joy St., Boston 8, Mass.)

11–15. Ionization Phenomena in Gases, 3rd internatl. conf., Venice, Italy. (U. Facchini, Laboratori CISE, Via Procaccini 1, Milan, Italy.)

12–15. Colloquium of College Physicists, 19th annual, Iowa City, Iowa. (J. A. Van Allen, Dept. of Physics, State Univ. of Iowa, Iowa City.)

13–15. Instrumental Methods of Analysis, 3rd natl. symp., Chicago, Ill. (H. S. Kendler, Instrument Soc. of America, 313 Sixth Ave., Pittsburgh 22, Pa.)

16–20. American Soc. of Mammalogists, annual, Lawrence, Kansas. (B. P. Glass, Dept. of Zoology, Oklahoma A.&M. College, Stillwater.)

16–21. American Soc. for Testing Materials, Atlantic City, N.J. (R. J. Painter, ASTM, 1916 Race St., Philadelphia 3.)

17–19. American Neurological Assoc., Atlantic City, N.J. (C. Rupp, 133 S. 36 St., Philadelphia 4, Pa.)

17–19. Astronomical Soc. of the Pacific, annual, Flagstaff, Ariz. (S. Einarsson, Univ. of California, Berkeley 4.)

17–19. Health Physics Soc., 3rd annual, Pittsburgh, Pa. (H. W. Patterson, Radiation Lab., Univ. of California, Berkeley.)

17–19. Military Electronics, national convention, Washington, D.C. (G. Rappaport, Emerson Radio & Phonograph Corp., 701 Lamont St., NW, Washington 10.)

17–20. Carbon Conf., 3rd, Buffalo, N.Y. (Carbon Conf., Univ. of Buffalo, Buffalo.)

17–20. Institute of Aeronautical Sciences, natl. summer, Los Angeles, Calif. (S. P. Johnston, IAS, 2 E. 64 St., New York 21.)

17–21. American Soc. for Engineering Education, annual, Ithaca, N.Y. (W. L. Collins, Univ. of Illinois, Urbana.)

17–21. Association of Official Seed Analysts, annual, Baton Rouge, La. (L. C. Shenberger, Seed Lab., Dept. of Agricultural Chemistry, Purdue Univ., Lafayette, Ind.)

17–21. Canadian Medical Assoc., 90th annual, Edmonton, Alberta, Canada. (CMA, 244 George St., Toronto, Ont.)

17–22. Coordination of Galactic Research, internatl. symp., Stockholm, Sweden. (P. T. Oosterhoff, University Observatory, Leiden, Netherlands.)

17–22. Internal Combustion Engine Cong., 4th internatl., Zurich, Switzerland. (C. C. M. Logan, British National Committee, 6 Grafton St., London, W.1.)

17–28. Wear Theory in Metal Cutting and Bearing Design, special summer program, Cambridge, Mass. (Massachusetts Inst. of Technology, Cambridge 39.)

19–21. Association for Computing Machinery, annual, Houston, Tex. (J. Moshman, ACM, 2 E. 63 St., New York 21.)

19–21. Society for the Study of Development and Growth, 16th annual symp., Kingston, R.I. (R. O. Erickson, SSDG, Botanical Lab., Univ. of Pennsylvania, Philadelphia 4.)

20–22. American Assoc. of Physics Teachers, annual, Schenectady, N.Y. (F. Verbrugge, School of Physics, Univ. of Minnesota, Minneapolis.)

20–22. American Physical Soc., Notre Dame, Ind. (K. K. Darrow, APS, Columbia Univ., New York 27.)

20–22. Soc. of Nuclear Medicine, 4th annual, Oklahoma City, Okla. (R. Lackey, SNM, 452 Metropolitan Bldg., Denver, Colo.)

21–23. American Assoc. of Bioanalysts, annual, New Orleans, La. (G. Hoffman, 3707 Gaston, Suite 419, Dallas, Tex.)

22–28. American Soc. of Medical Technologists, annual, Chicago, Ill. (Miss R. Matthaei, ASMT, Suite 25, Hermann Professional Bldg., Houston 25, Tex.)

23–26. American Soc. of Agricultural Engineers, E. Lansing, Mich. (J. L. Butt, ASAE, St. Joseph, Mich.)

23–28. American Physical Therapy Assoc., annual, Detroit, Mich. (Miss M. E. Haskell, APTA, 1790 Broadway, New York 19.)

23–28. National Assoc. of Power Engineers, natl., Grand Rapids, Mich. (E. J. Schuetz, NAPE, 176 W. Adams St., Chicago 3, Ill.)

23–29. American Library Assoc., annual, Kansas City, Kans. (D. H. Clift, ALA Hq., 50 E. Huron St., Chicago 11, Ill.)

23–30. Rheumatic Diseases, 9th internatl. cong., in conjunction with American Rheumatism Assoc., Toronto, Ont., Canada. (E. Dunlop, Box 237, Terminal "A," Toronto.)

24–26. Aging, 10th conf., Ann Arbor, Mich. (Div. of Gerontology, Univ. of Michigan, Rackham Bldg., Ann Arbor.)

24–26. American Soc. of Heating and Air-Conditioning Engineers, Murray Bay, Quebec, Canada. (A. V. Hutchinson, ASHAE, 62 Worth St., New York 13.)

24–27. Agricultural Inst. of Canada, with six other Canadian agricultural socs., annual, Vancouver, B.C. (W. J. Anderson, Dept. of Agricultural Economics, Univ. of British Columbia, Vancouver.)

24–28. American Inst. of Electrical Engineers, summer general, Montreal, Quebec, Canada. (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

24–28. Scientific Management, 11th internatl. cong., Paris, France. (Internatl. Committee of Scientific Management, 57, rue de Babylone, Paris 7e.)

24–29. Cosmical Gas Dynamics, 3rd symp. (by invitation), Internatl. Union of Theoretical and Applied Mechanics, Cambridge, Mass. (J. M. Burgers, Univ. of Maryland, College Park.)

25–27. Max Planck Soc. for the Advancement of Science, annual general assembly, Lübeck, Germany. (Max Planck Soc. for the Advancement of Science, Kaiserwertherstrasse 164, Dusseldorf, Germany.)

25–28. American Dairy Science Assoc., 51st annual, Stillwater, Okla. (H. F. Judkins, 32 Ridgeway Circle, White Plains, N.Y.)

25–28. American Home Economics Assoc., St. Louis, Mo. (Miss M. Horton, AHEA, 1600 20 St., NW, Washington 9.)

30–1. National Education Assoc., annual, Philadelphia, Pa. (W. G. Carr, NEA, 1201 16 St., NW, Washington 6.)

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July

1–3. Reproduction and Infertility, 3rd symp., Fort Collins, Colo. (F. X. Gassner, Colorado State Univ., Fort Collins.)

1–6. Brazilian Soc. for the Advancement of Science, 9th annual, Rio de Janeiro, Brazil. (Sociedade Brasileira Para o Progresso da Ciencia, Caixa Postal 2926, São Paulo, Brazil.)

1–6. Industrial Medicine, 12th internatl. cong., Helsinki, Finland. (L. Noro, Inst. of Occupational Health, Huapalahdenkatu 1, T8818, Helsinki.)

2–4. Neurological Basis of Behavior, Ciba Foundation Symp. (by invitation only), London, England. (G. E. W. Wolstenholme, Ciba Foundation, 41 Portland Pl., London, W.1.)

2–6. Physical Problems of Color Television, internatl. symp. of IUPAP, Paris, France. (Secretary, Colloque International sur les Problèmes de la Télévision en Couleurs, Conservatoire National des

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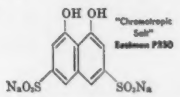

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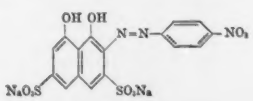

with which you can spot-test for borates, according to Feigl. Unless you need the exercise, that would be a little quixotic because you can buy the reagent as *4,5-Dihydroxy-3-(p-nitrophenylazo)-2,7-naphthalenedisulfonic Acid Disodium Salt* (Eastman 4411).

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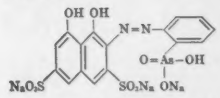

which democrat or monarchist can purchase as *3-(2-Arsonophenylazo)-4,5-dihydroxy-2,7-naphthalenedisulfonic Acid Trisodium Salt* (Eastman 7302, with the name slurred to "Arsenazo"). If he reads and believes scientific Russian, he may buy it for the determination of beryllium, rare earths (as a group), and aluminum in Al-Ni-Cr and Al-Mg alloys. (We'll supply the references, if asked.)

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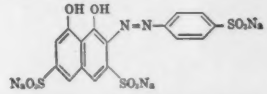

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3–6. Current Problems in Crystal Physics, conf. IUPAP and NSF, Cambridge, Mass. (J. S. Slater, Massachusetts Inst. of Technology, Cambridge 39.)

8–10. Astrophysical Symp., 8th internl., Liége, Belgium. (P. Swings, Institut d'Astrophysique, Université de Liége, Liége.)

8–10. Endocrine Aspect of Breast Cancer, Internatl., conf., Glasgow, Scotland. (A. P. M. Forrest, Dept. of Surgery, Western Infirmary, Glasgow, W.1.)

8–12. Inter-American Cong. of Philosophy, 5th, Washington, D.C. (R. M. Chisholm, Brown Univ., Providence, R.I.)

8–12. Poliomyelitis Conf., 4th internatl., Geneva, Switzerland. (Secretariat, 4th International Poliomyelitis Conference, Hotel du Rhone, Geneva.)

9–11. Biological Symp., 8th annual, Univ. of Michigan, Ann Arbor. (B. L. Baker, Dept. of Anatomy, Univ. of Michigan, Ann Arbor.)

9–13. European Molecular Spectroscopy Conf., Freiburg, Breisgau, Germany. (R. Mecke, Dept. of Physical Chemistry, Univ. of Freiburg, Freiburg.)

9–13. International Cong. for the Study of Social Insects, Paris, France. (G. Richard, International Union for the Study of Social Insects, Faculty of Sciences, University of Rennes, Rennes, France.)

10–12. Thermodynamic and Transport Properties of Fluids, conf., IUPAC, London, England. (Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W. 1.)

10–17. International Union of Crystallography, 4th genl. assembly, Montreal, Canada. (G. A. Jeffrey, Chemistry Dept., Univ. of Pittsburgh, Pittsburgh 13, Pa.)

14–19. International Assoc. of Gerontology, Merano, Italy. (A. I. Lansing, Dept. of Anatomy, Univ. of Pittsburgh, Pittsburgh 13, Pa.)

14–20. Clinical Pathology, 4th internatl. cong., Brussels, Belgium. (M. Welsch, Service de Bacteriologie et de Parasitologie, Université de Liége, Blvd. de la Constitution, Liége, Belgium.)

15–19. Institute on College Administration, annual, Ann Arbor, Mich. (A. D. Henderson, 2442 U.E.S., Univ. of Michigan, Ann Arbor.)

16–19. American Malacological Union, annual, New Haven, Conn. (Miss M. C. Teskey, P.O. Box 238, Marinette, Wis.)

16–24. International Cong. for Pure and Applied Chemistry, 16th, Paris, France (R. Morf, Secy. Genl., IUPAC, Sandoz, S.A., Basel, Switzerland.)

20–21. Medical-Sociological Aspects of Senile Nervous Diseases, internatl. symp., Venice, Italy. (S. N. Feingold, Jewish Vocational Service of Greater Boston, 70 Franklin St., Boston 10, Mass.)

21–28. Neurological Sciences, 1st internatl. cong., Brussels, Belgium. (P. Bailey, National Institutes of Health, Bethesda 14, Md.)

23–24. Modern Electrochemical Methods of Analysis, Internatl. symp., Paris, France. (G. Charles, Ecole Superieure de Physique et de Chimie, 10, rue Vauquelin, Paris 5e.)

25–26. Structure Properties Relationships of Polymers (IUPAC), Paris France. (International Union of Pure and Applied Chemistry, 4, Avenue de l'Observatoire, Paris 6e.)

25–29. Protein Chemistry Symp., IUPAC, Paris, France. (J. Roche, College de France, Place Marcellin Berthelot, Paris 5e.)

26–27. Experimental Psychology and Animal Behavior Section of International Union of Biology, Brussels, Belgium. (H. S. Langfeld, Dept. of Psychology, Princeton Univ., Princeton, N.J.)

26–27. Linguistic Soc. of America, Ann Arbor, Mich. (A. A. Hill, Box 7790, University Station, Austin 12, Tex.)

26–27. Military Psychology, internatl. symp., Brussels, Belgium. (National Academy of Sciences, 2101 Constitution Ave., NW, Washington 25.)

26–1. International Congress on Nutrition, 4th, Paris, France. (Quatrième Congrès International de Nutrition, CNERNA, 71, boulevard Péreire, Paris 17e.)

28–1. Psychoanalysis, 20th internatl. cong., Paris, France. (Dr. Nacht, 187, rue Saint-Jacques, Paris 5.)

28–3. Psychology, 15th internatl. cong., Brussels, Belgium. (L. Delys, 296, avenue des Sept Bonniers, Forest-Bruxelles.)

31–5. International Assoc. for Hydraulic Research, Lisbon, Portugal. (M. Coelho Mendes da Rocha, Laboratorio Nacional de Engenharia Civil, Avenida do Brasil, Lisbon.)

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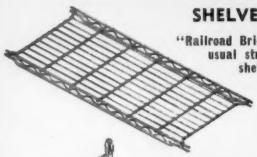

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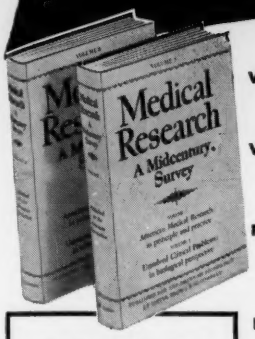

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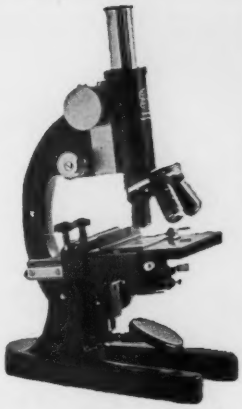

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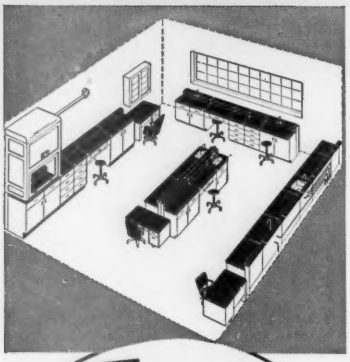

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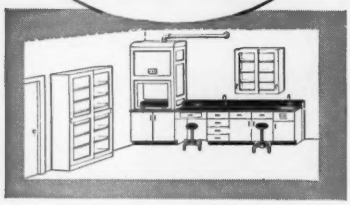

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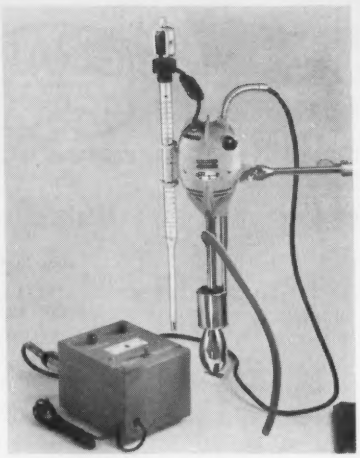

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31–6. Dermatology, 11th internatl. cong., Stockholm, Sweden. (C. H. Floden, Hudkliniken, Karolinska Sjukhuset, Stockholm 60.)

August

5–11. Pan American Cong. of Pediatrics, 5th, Lima, Peru. (C. F. Krumdieck, Washington 914, Lima.)

5–17. Curare and Curare-Like Agents, internatl. symp., Rio de Janeiro, Brazil. (C. Chagas, Instituto de Biofisica, Universidade do Brasil, 458 Avenida Pasteur, Rio de Janeiro.)

6–9. Poultry Science Assoc., annual, Columbia, Mo. (C. B. Ryan, Texas A.&M. College, College Station.)

7–9. Industrial Applications of X-Ray Analysis, 6th annual conf., Denver, Colo. (J. P. Blackledge, Metallurgy Div., Denver Research Inst., Univ. of Denver, Denver 10.)

7–9. International Union against the Venereal Diseases and the Treponematoses, 31st general assembly, Stockholm, Sweden. (Secretary General, Institut Alfred Fournier, 25, boulevard Saint-Jacques, Paris 14e, France.)

8–15. International Statistical Inst., 30th, Stockholm, Sweden. (Secretary General, ISI 30th Session, Fack, Stockholm 5.)

8–15. International Union for the Scientific Study of Population, Stockholm, Sweden. (F. Lorimer, c/o American University, Washington 16.)

11–14. Heat Transfer, national conf., University Park, Pa. (G. M. Dusinberre, Pennsylvania State Univ., University Park.)

11–17. World Federation for Mental Health, 10th annual, Copenhagen, Denmark. (Miss E. M. Thornton, 19 Manchester St., London, W.1, England.)

12–16. Canadian Teachers' Federation, annual, Edmonton, Alberta, Canada. (G. G. Croskery, 444 MacLaren St., Ottawa 4, Ont.)

12–18. Theory of Functions, internatl. colloquium, Helsinki, Finland. (B. Eckmann, Ecole Polytechnique, Federale, Zurich, Switzerland.)

12–25. International Soc. of Soil Mechanics and Foundation Engineering, 4th Conf., London, England. (A. Banister, Institution of Civil Engineers, Great George St., London, S.W.1.)

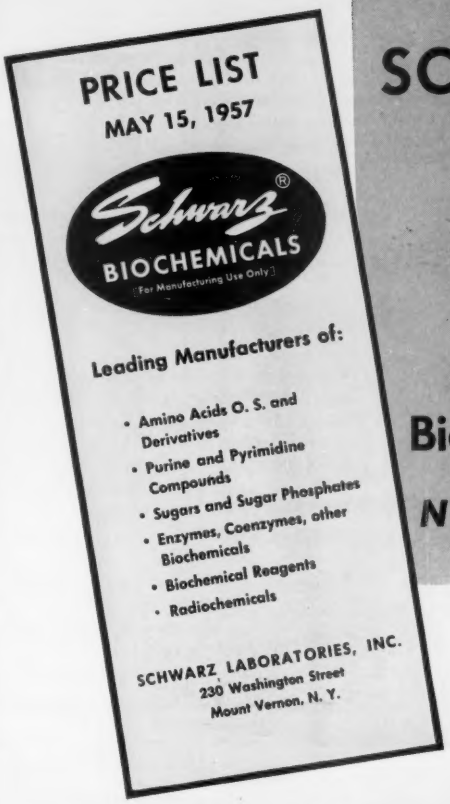
18–21. American Astronomical Soc., Urbana, Ill. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.)

19–22. American Veterinary Medical Assoc., annual, Cleveland, Ohio. (J. G. Hardenbergh, AVMA, 600 S. Michigan Ave., Chicago 5, Ill.)

19–23. Clay Conf., 6th natl., Berkeley, Calif. (Dept. of Conferences and Special Activities, Univ. of California Extension, Berkeley 4.)

19–23. Clinical Chemistry, 2nd international European cong., Stockholm, Sweden. (K. Agner, Box 12024, Stockholm 12.)

19–24. Finite Groups, internatl. colloquium, Tübingen, Germany. (H. Wielandt, Faculty of Mathematics and Natural Science, Eberhard-Karls-Universität, Tübingen.)



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The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science *does not assume responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to* Science, *Room 740, 11 W. 42 St., New York 36, N.Y. Include the name(s) of the manufacturer(s) and the department number(s).*

■ AMPLIFIER is designed for laboratory applications requiring high input impedance and broad-band response. Frequency response is flat from ½ cy/sec to 2 Mcy/sec. Input impedance ranges from 0.1 to 500 Mohm. Up to ten amplifiers fit side by side in a 19-in. relay rack. (Atlantic Research Corp., Dept. S299)

■ VACUUM VALVE for pressures of 10^{-10} mm-Hg and lower has an effective conductance for nitrogen of 1×10^{-11} lit/sec. The valve can be baked at temperatures up to 450°C. The valve assembly consists of a Monel cup sealed off by a flexible Monel diaphragm. Closure is effected by metal-to-metal contact between a nose piece carried by the diaphragm and a 0.25-in. orifice. (Consolidated Electrodynamics Corp., Dept. S345)

■ X-RAY ANALYZER designed for the continuous analysis of a single element utilizes x-ray fluorescence, measuring the ratio of fluorescent radiation characteristic of the element to scattered radiation. Spectral lines from 0.35 to 2.8 A may be employed. This permits measurement of elements from titanium to cerium by their K-spectra and of elements up to atomic number 100 by their L-spectra. A curved crystal of lithium fluoride is used as the dispersive element of the spectrometer. Results are presented on a strip-chart ratio recorder. Errors are said to be less than ±1 percent of full scale. (Applied Research Laboratories, Dept. S331)

■ ELECTRON TUBE TESTER uses perforated cards to effect the proper circuit adjustments for tube testing. The testing procedure consists of insertion of the tube, selection of the card appropriate to the tube type, and pushing of buttons to observe quality. (Hickok Electrical Instrument Co., Dept. S245)

■ FREQUENCY STANDARD employs a stabilized tuning fork to generate a 400 cy/sec signal with an accuracy of ±0.005 percent. Operation is on 115-v, 60-cy/sec power. (Industrial Test Equipment Co., Dept. S319)

■ MICROFILM CAMERA assembly consists of a book-holder base, a metal column, and a camera. The camera operates on a 3-sec cycle per exposure. One second is devoted to the actual exposure. Adjustment to four sizes of the area to be copied is provided. (A. Seidell, Dept. S249)

■ THERMAL CONDUCTIVITY CELL for chromatographic analysis operates over a range of 30° to 325°C and accommodates liquids with boiling points up to 425°C. Flake thermistors are used as temperature-sensing elements. The detector is constructed of stainless steel and enclosed in an oven in which the temperature is continuously variable from 30° to 350°C. Resistance is measured by a Wheatstone bridge designed for use with flake thermistors. (Barnes Engineering Co., Dept. S330)

■ AUTOMATIC ANALYZERS for total hardness and silica content perform continuous analysis and record results. Both instruments utilize colorimetric methods. Total hardness determination is based on complex formation of calcium and magnesium with a dye. Silica determination is based on formation of colloidal molybdenum blue. The operating cycles of the instruments simulate closely the corresponding manual operations. Standard range of the hardness analyzer is 0 to 3 (Moh) and of the silica analyzer 0 to 0.2. (Milton Roy Co., Dept. S314)

■ DEWAR FLASKS of stainless steel have a radiant heat transfer of less than 3000 cal/hr at 300°F ambient, with temperature of contents 40°F. Conduction through the neck in a 4-in. length is less than 20 cal/hr deg C. The flasks are of welded construction. (Consolidated Electrodynamics, Dept. S350)

■ ROENTGEN METER measures gamma and x-ray rates in body cavities. The detecting element is an anthracene crystal mounted in a slender probe. The probe is designed to avoid corrections for radiation hardness. The probe and cable can be sterilized by alcohol immersion. (NRD Instrument Co., Dept. S297)

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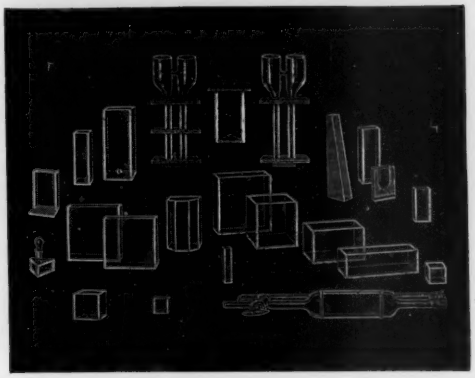

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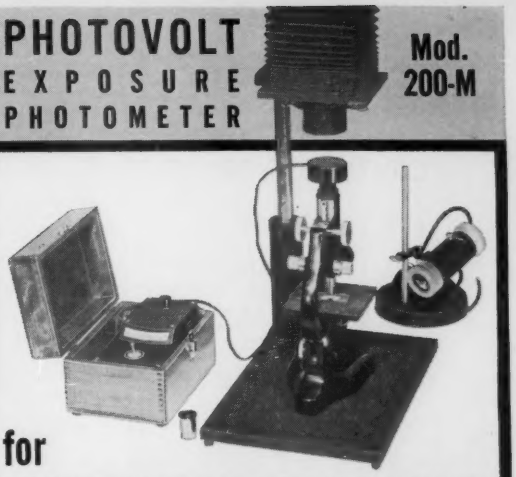

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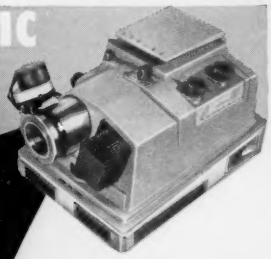

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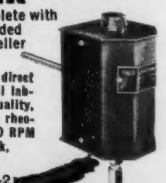

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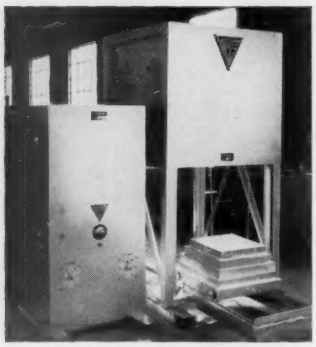

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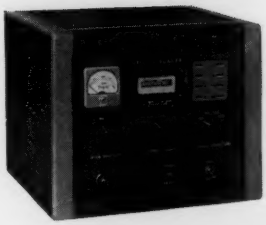

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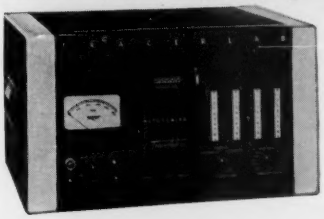

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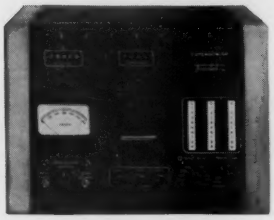

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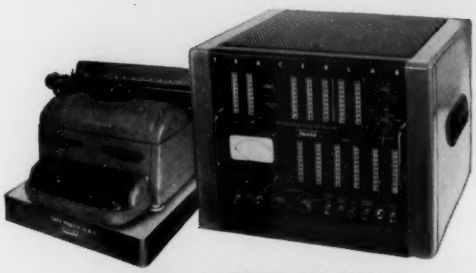

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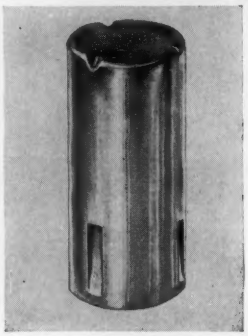

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